# Cummins Engine – Lakewood, NY

AGV MAINTENANCE TRAINING

INSTRUCTOR: JOHN SCIANNA

# TRAINING OBJECTIVES

1. **Understand the overall AGV system and how the material movement is accomplished.**
2. **Understand how the AGVs communicate to the Vehicle Management System and to each other for traffic control.**
3. **Understand how the AGV navigates and guides the path to accomplish moving material.**
4. **Understand how the AGV and all its sub-systems operate.**
5. **Be able to interpret the AGV schematic and use it for troubleshooting.**
6. **Learn how to use the AGV diagnostics to check all sensors and inputs to determine which item is not operating correctly.**
7. **Learn how to operate the AGV and initialize it to introduce into the system.**
8. **Learn troubleshooting techniques to help isolate an AGV fault and what caused it to happen.**
9. **Become familiar with the Maintenance Manual to help personnel troubleshoot, repair, operate, and order parts for the AGV system.**

# AGV SYSTEM OVERVIEW

- The unit load DC60 AGVs will replace the existing DC40 differential drive AGVs.
- Five (5) Savant model DC-60 AGVs that were rebuilt from the Columbus, IN facility. The AGVs will continue to support the engine delivery missions
- A Vehicle Manager System (VMS) will be used, as part of the Automated Guided Vehicle System (AGVS), to assign the vehicle-specific retrieval based on delivery missions received from the Cummins PLC. The VMS will be upgraded to Windows XP operating system.
- AGView Computer to record and monitor AGV activity.The computer will also graphically display AGV system guide path.

# GENERAL AGV OVERVIEW

- Unit Load Carrier with a powered roller deck (front/rear transfers) and 6000 pound carrying capacity.
- Wireless Guidance using a virtual path with Gyro, Magnet Sensor, and Ground Track Sensor.
- RF Communications via the Constant System Monitor (CSM) to VMS Computer for AGV dispatching. Traffic Control between the AGVs using RF Communications via the CSM, a Base Station and system wide antenna.
- Three wheel configuration with independent Front and Rear Steering.
- CAN Bus (Network) Communications between computers, controllers and I/O on the AGV.
- Four Quadrant PWM control to drive the traction motor/drive.

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# AGV Outline

# SYSTEM OPERATION

- The AGV system will operate as it exists today with the exception of the local handshake control at each pick/drop station.
- A Hokuyo model DMS-GA1, 4-Channel Optical Data Transmission Device will be used for the AGV and Engine Test Cell load transfer handshake. Each handshake device has four transmitters and four receivers that may be independently or simultaneously operated. The AGV will be equipped with two device locations, one at each end of the AGV (See AGV outline drawing) to replace the existing handshake optics, entry optic, and floor beacon.
- The Hokuyo Data Transmission Device will require a 24 VDC power source and the Cell controller will need at least one (1) input and three (3) outputs for the interface. Channel 1 (Transmit and Receive) will be used to replace the existing Omron handshake optic pair and the operation will remain the same. Channel 2 will be used to replace the existing Omron entry optic and the operation will remain the same. Channel 3 will be used to replace the floor beacon and the operation will remain the same. Cummins may opt to eliminate channel 3 and the beacon functionality.

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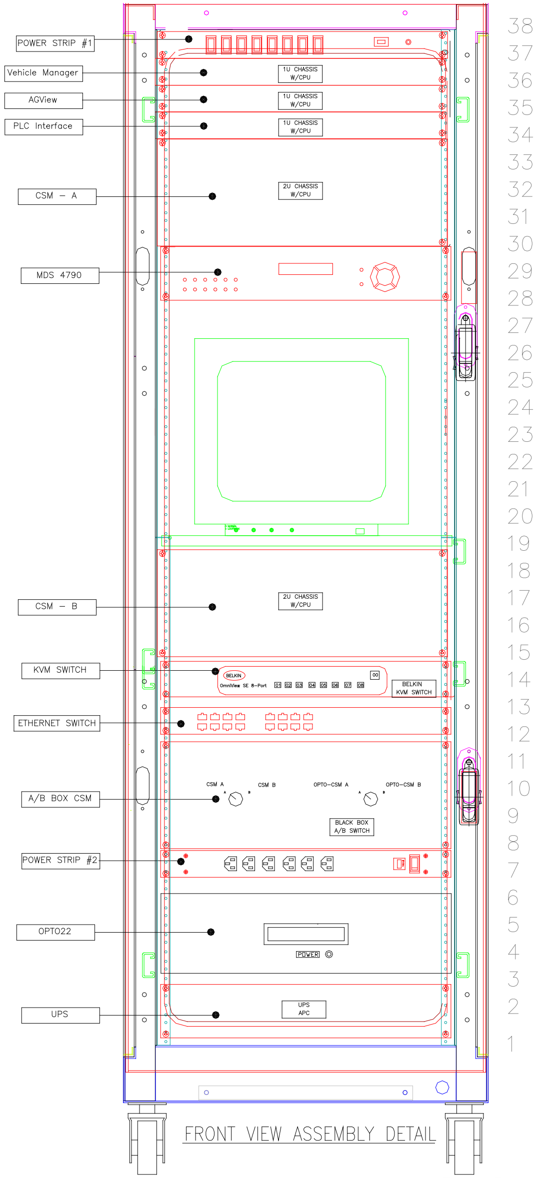
# Handshake Signals

| Wire Color | Function | Connection | Comment |
|---|---|---|---|
| Black | Channel #1 Transmitter | PLC-Output #1 | Handshake Transmit – same operation as today's handshake transmitter. |
| Brown | Channel #2 Transmitter | PLC-Output #2 | Entry Transmit - same operation as today's entry optic. |
| Red | Channel #3 Transmitter | PLC-Output #3 | Beacon Transmit – same operation as today's floor beacon input. |
| Orange | Channel #4 Transmitter | PLC-Output #4 | No connection |
| White/Yellow | Mode Control | --- | No Connection |
| Yellow | Select Control | --- | No Connection |
| White/Blue | N/C | --- | No Connection |
| Green | Channel #1 Receiver | PLC-Input #1 | Handshake Receive – same operation as today's handshake transmitter. |
| Blue | Channel #2 Receiver | PLC-Input #2 | No Connection |
| Purple | Channel #3 Receiver | --- | No Connection |
| Gray | Channel #4 Receiver | --- | No Connection |
| White | Go | --- | No Connection |
| Yellow/Green | COM - Chassis | Chassis | Earth |
| Yellow/Red | + VDC - IN | + 24 VDC Power | Source Power |
| Yellow/Black | - VDC - COM | + 0 VDC Power | Return Power |
| Shield | Shield | Chassis | Earth |

# CSM/RF COMMUNICATIONS

- CSM (CONSTANT SYSTEM MONITOR) CONTROLS COMMUNICATIONS TO THE AGVS VIA AN RF BASE STATION. TRAFFIC CONTROL INFORMATION (BLOCKING) IS ROUTED THRU THE CSM.
- VEHICLE RF TRANSCEIVER MODEM IS CONNECTED TO VEHICLE MICRO COMPUTER.
- NAVIGATION COMPUTER SENDS POSITON INFORMATION TO VEHICLE MICRO COMPUTER (VIRTUAL CODES).
- VIRTUAL CODES ARE USED FOR STATION STOPS, ROUTING AND TRAFFIC CONTROL (BLOCKING).
- THE VMS COMPUTER DISPATCHES THE AGVS VIA THE CSM/RF BASE STATION.
- VEHCILE TRANSMITS BLOCK ZONE TO CSM, WHICH THEN REPEATS IT TO ALL OTHER VEHICLES. (NONE IN MANUAL!!)
- REVIEW P. 53 THROUGH P.62 IN THE TROUBLESHOOTING SECTION OF THE MANUAL.
- REVIEW FIELD WIRING DRAWINGS.

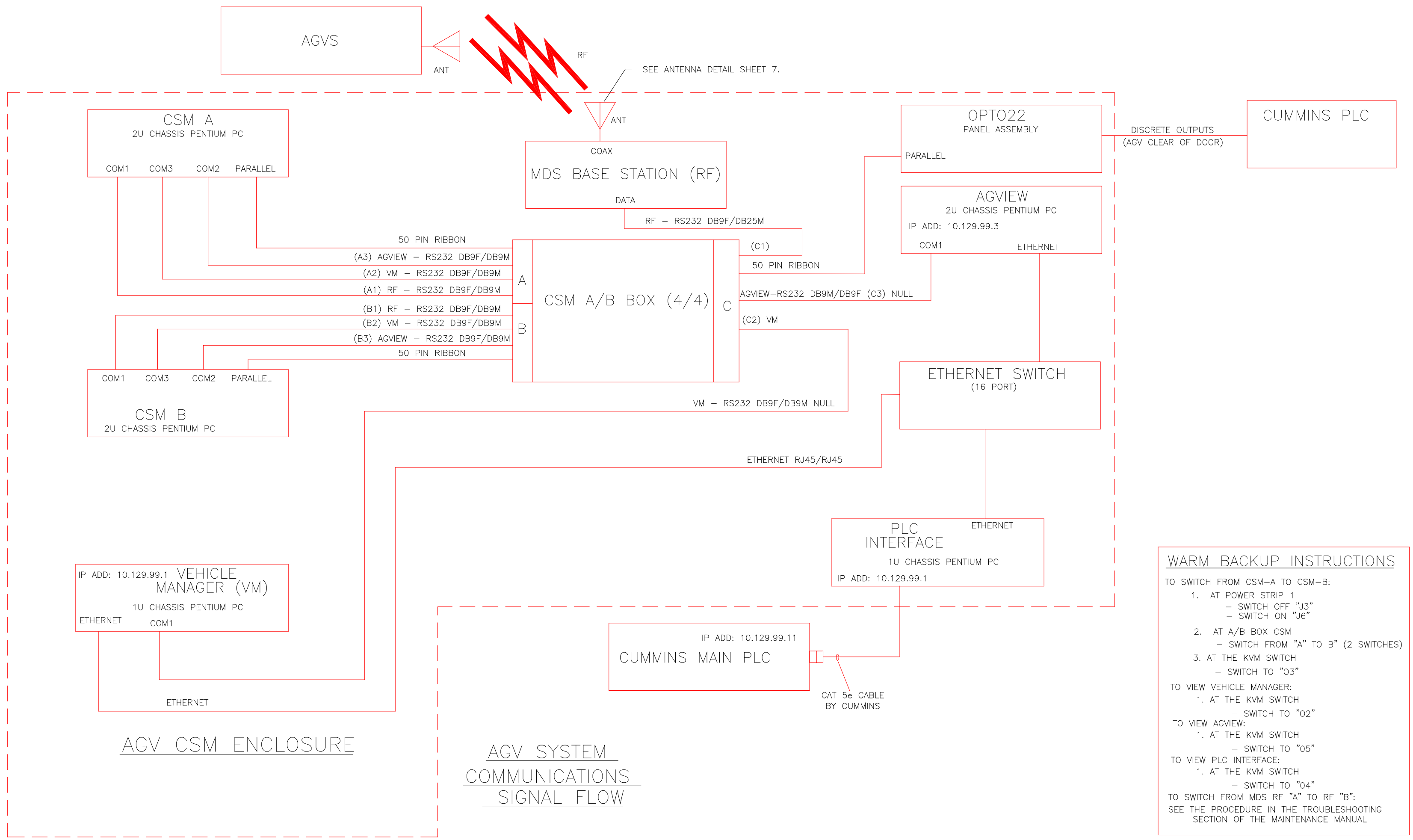
# AGV Control Enclosure






CSM Enclosure

# AGV System Communications Block Diagram



# VIRTUAL GUIDEPATH

- THE PATH EXISTS AS A FLOOR LAYOUT AUTO CAD DRAWING THAT IS LOADED INTO THE NAVIGATION COMPUTER'S MEMORY. MAGNETS ALONG THE PATH ARE USED AS THE REFERENCE POINTS, WHICH THE VEHICLE USES TO VERIFY ITS CALCULATED POSITION ON THE PATH WITH RESPECT TO TO THE PLANT.
- THE AGV ONLY CAN TRAVEL ON THAT PREDETERMINED VIRTUAL WIRE.
- THE DRAWING IS CONVERTED TO A DXF FILE (TRACK FILE) AND LOADED INTO THE NAVIGATION COMPUTER.
- THE TRACK ERROR CAN BE DISPLAYED USING THE CDU DIAGNOSTICS AND SHOULD BE LESS THAN 1" ON A STRAIGHT PATH. SEE P.25 AND 26 IN TROUBLESHOOTING.
- FOR ROUTING PURPOSES MULTIPLE PATHS ARE UTILIZED. THE AGV TRAVELS ALONG THE CURRENT PATH UNTIL TOLD TO CHANGE PATHS BY THE VEHICLE COMPUTER.

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# VIRTUAL CODES

- THESE CODES DO NOT PHYSICALLY EXIST, BUT ARE EMBEDDED INTO THE NAVIGATION SOFTWARE.
- THEY ARE PLACED THROUGHOUT THE GUIDEPATH TO HANDLE TRAFFIC CONTROL, ROUTING, STATION STOPS AND ACTIONS.
- THE VIRTUAL CODE # IS USED BY THE VEHICLE COMPUTER TO PERFORM THE ABOVE FUNCTIONS. THE NAVIGATION COMPUTER TRANSMITS THE VIRTUAL CODE # TO THE VEHICLE COMPUTER.
- VIRTUAL CODES ARE DESIGNATED BY A 3-DIGIT CODE ON THE BLOCKING LAYOUT DRAWING. THEY CAN ALSO BE DISPLAYED USING THE DIAGNOSTIC SCREEN ON THE AGV DISPLAY. SEE P. 14 IN TROUBLESHOOTING.

# PATH LAYOUTS

- GUIDEPATH LAYOUT SHOWS PATH WITH ALL MAGNET LOCATIONS. MAGNET ID # IS IDENTIFIED WITH A 4-DIGIT NUMBER.
- INITIALIZATION POINT (IP) MAGNETS ARE INDICATED ON THE LAYOUT. EACH IP POINT IS UNIQUE AND IS DIFFERENTIATED BY A DIFFERENT DISTANCE BETWEEN THE TWO MAGNETS AT EACH LOCATION.
- THE BLOCKING LAYOUT SHOWS THE DIFFERENT PATHS FOR ROUTING AND SHOWS ALL VIRTUAL CODES. VIRTUAL CODES ARE IDENTIFIED BY A 3-DIGIT NUMBER.
- ON THE BLOCKING LAYOUT; STATION #, ACTION #, ROUTING DECISION #, AND BLOCKING (TRAFFIC CONTROL) ARE IDENTIFIED. MULTIPLE PATHS ARE USED FOR ROUTING.
- REVIEW SYSTEM PATH AND BLOCKING LAYOUTS.

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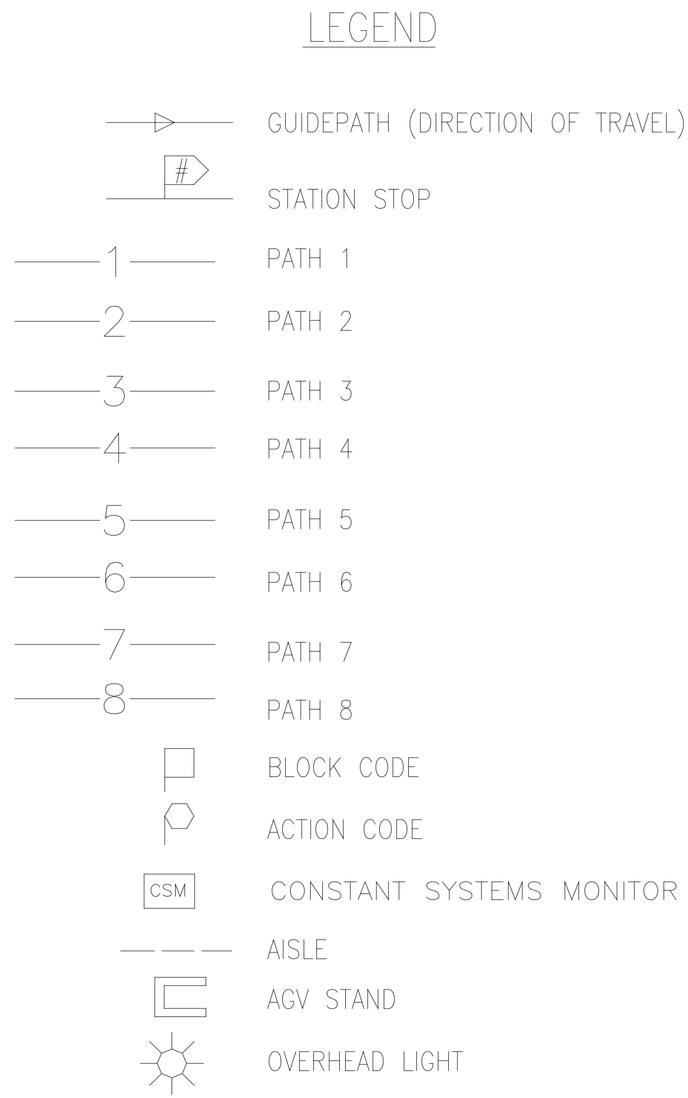
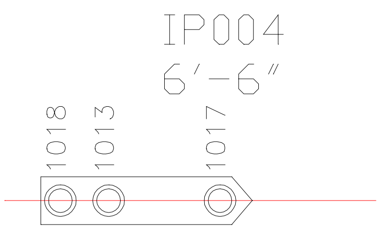
# PATH SYMBOLS




**IP LOCATION**



# BLOCKING (TRAFFIC CONTROL)

- BLOCK ZONE (#) IS TRANSMITTED TO ALL OTHER AGVS VIA CSM THROUGH RF SYSTEM.
- STRAIGHT LINE BLOCKING
- CONVERGENCE BLOCKING
- CROSSING BLOCK
- VIRTUAL CODE # DETERMINES WHICH BLOCK # IS
- ROUTING - At Divergences, the AGV will decide which path to take based on its programmed destination.

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# STRAIGHT LINE & CONVERGENCE BLOCKING

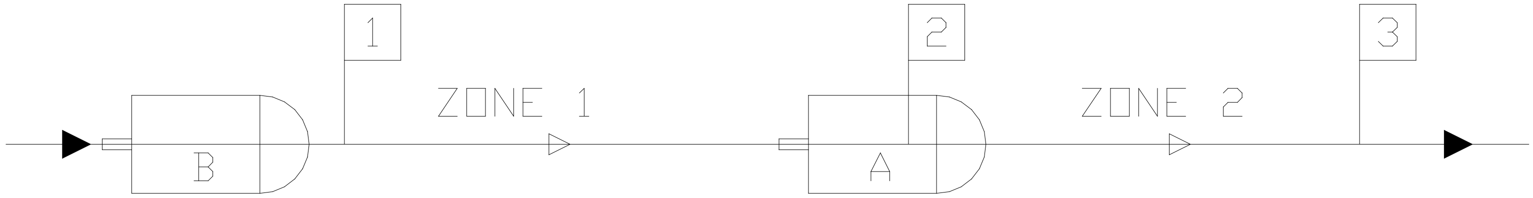


FIGURE 2-1

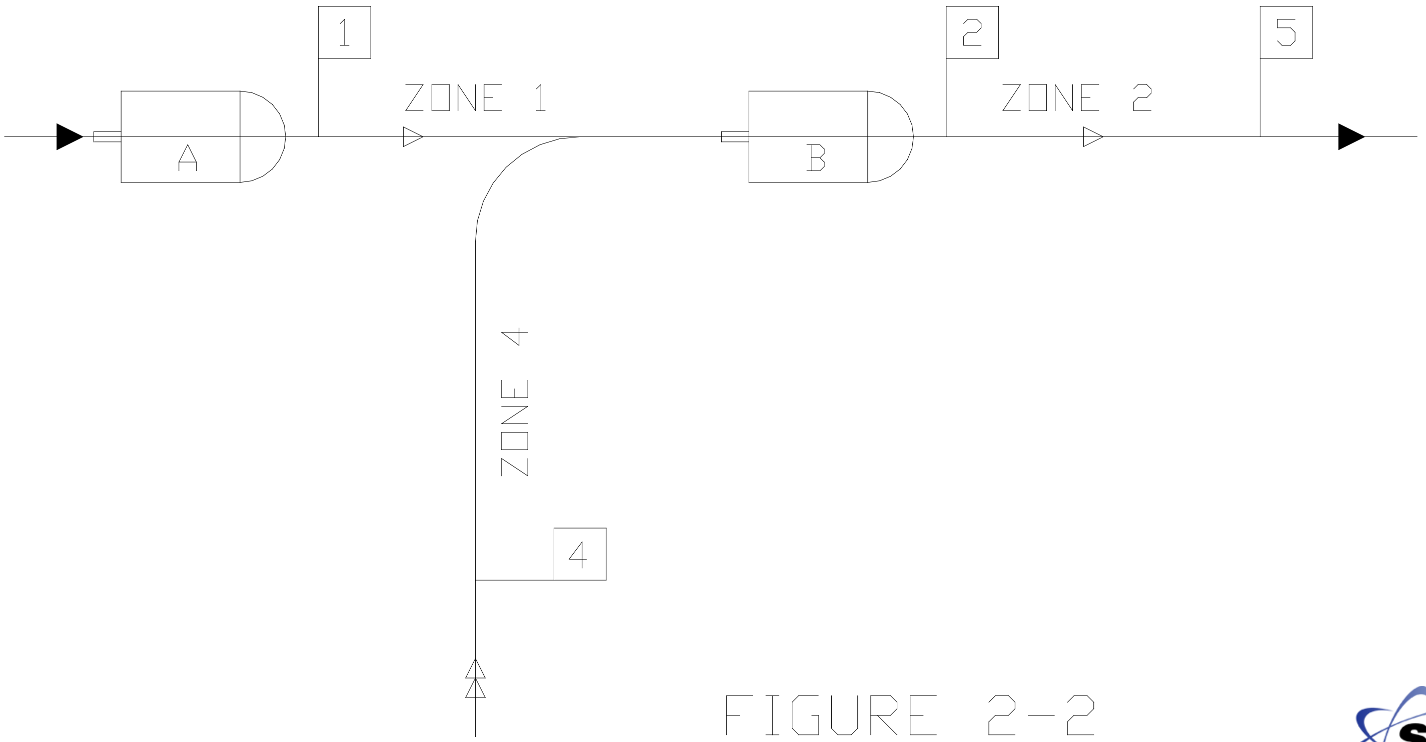


FIGURE 2-2

# CROSSING BLOCKING

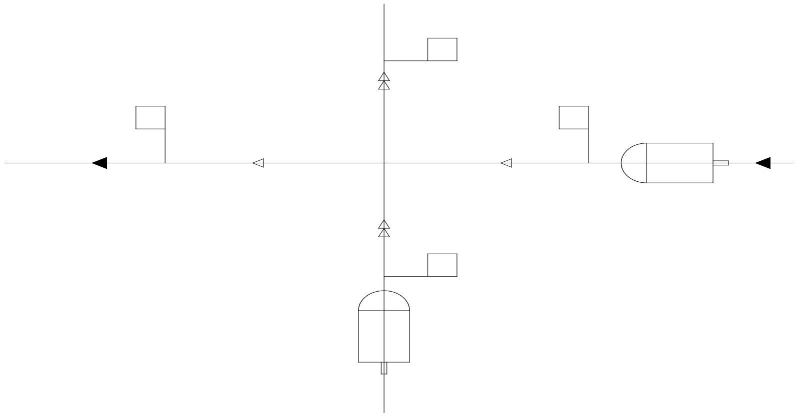

FIGURE 2-4

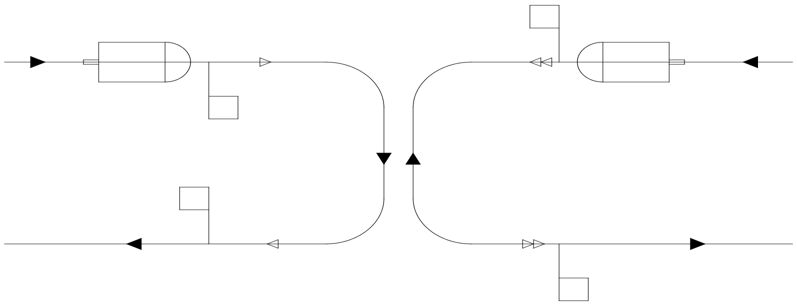

FIGURE 2-5

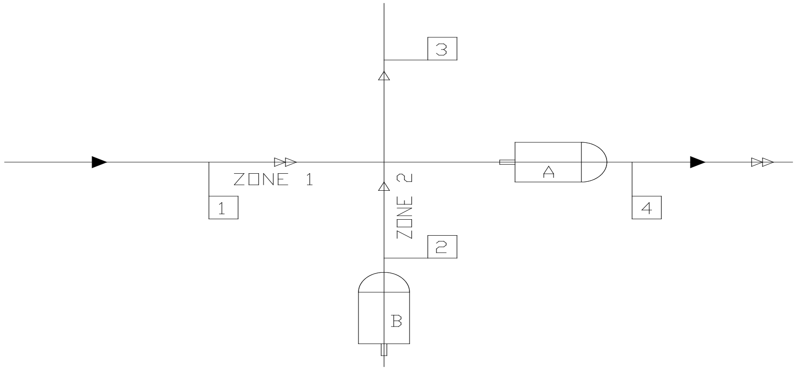


FIGURE 2-6

# AGV Diagnostics

- The DC60 AGV has a variety of control display unit (CDU) functions designed to help trained maintenance personnel to determine the cause of various malfunctions. These functions are accessed by pressing the ***blank key under the "9" key four times***. Diagnostic mode is not a dispatching mode but a maintenance function. Only properly trained maintenance personnel should attempt to use this function. The AGV will operate automatically with diagnostic mode selected.
- The diagnostic mode menu tree is shown in the figure (see page 8 in trouble shooting). The available diagnostic functions have been designed in two levels: basic functions and advanced. The version, RFComm, and status modes are basic functions and are accessed by pressing the number under that group. Individual functions under each group are accessed using the arrow keys..

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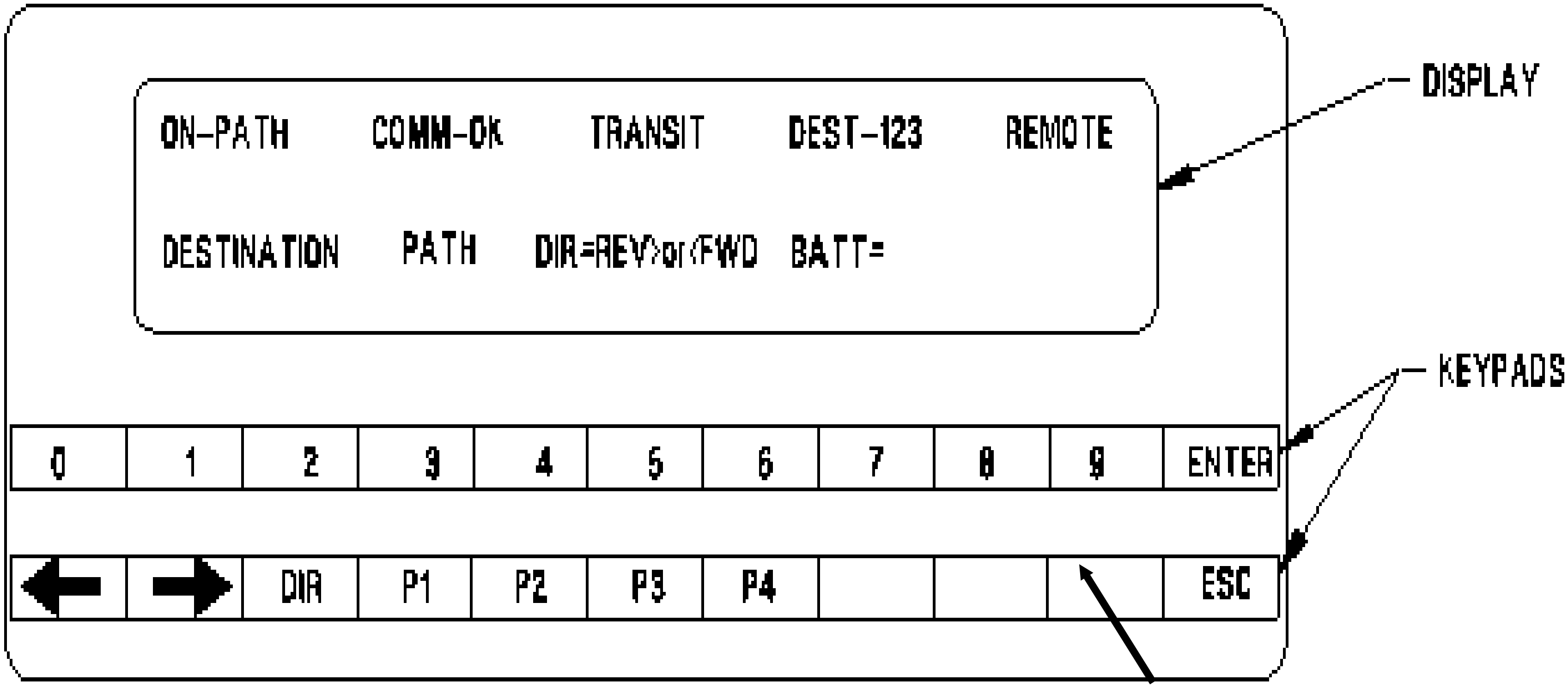
# AGV Diagnostics



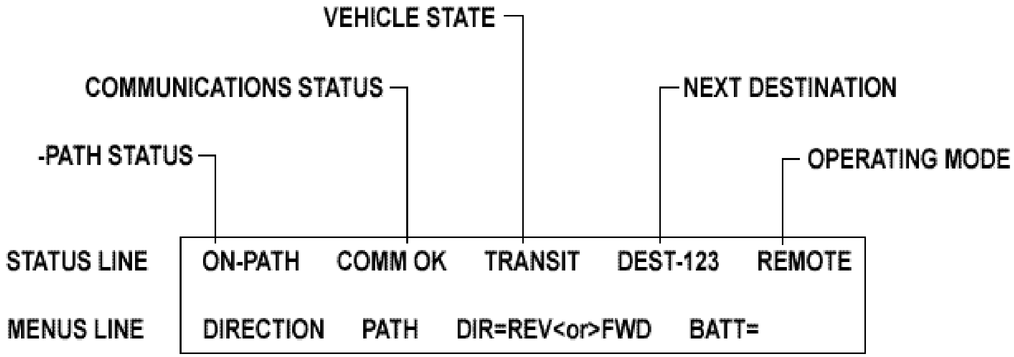

PRESS 4 TIMES TO ACCESS
DIAGNOSTICS

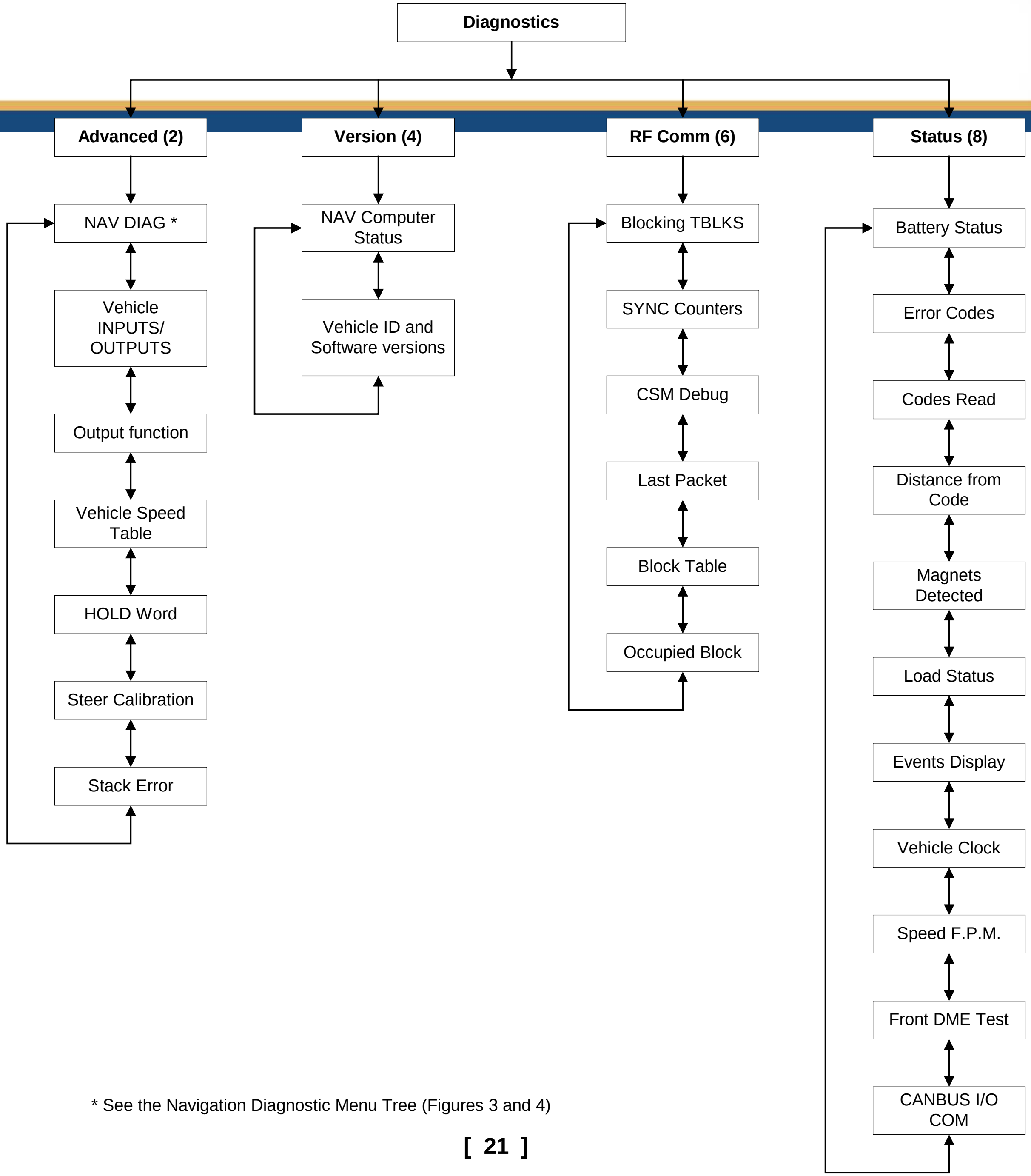
Figure 1 Main Diagnostic screen

| |
|---|
| Press key under group desired: (or ESC) |
| Advanced Version RF Comm Status |

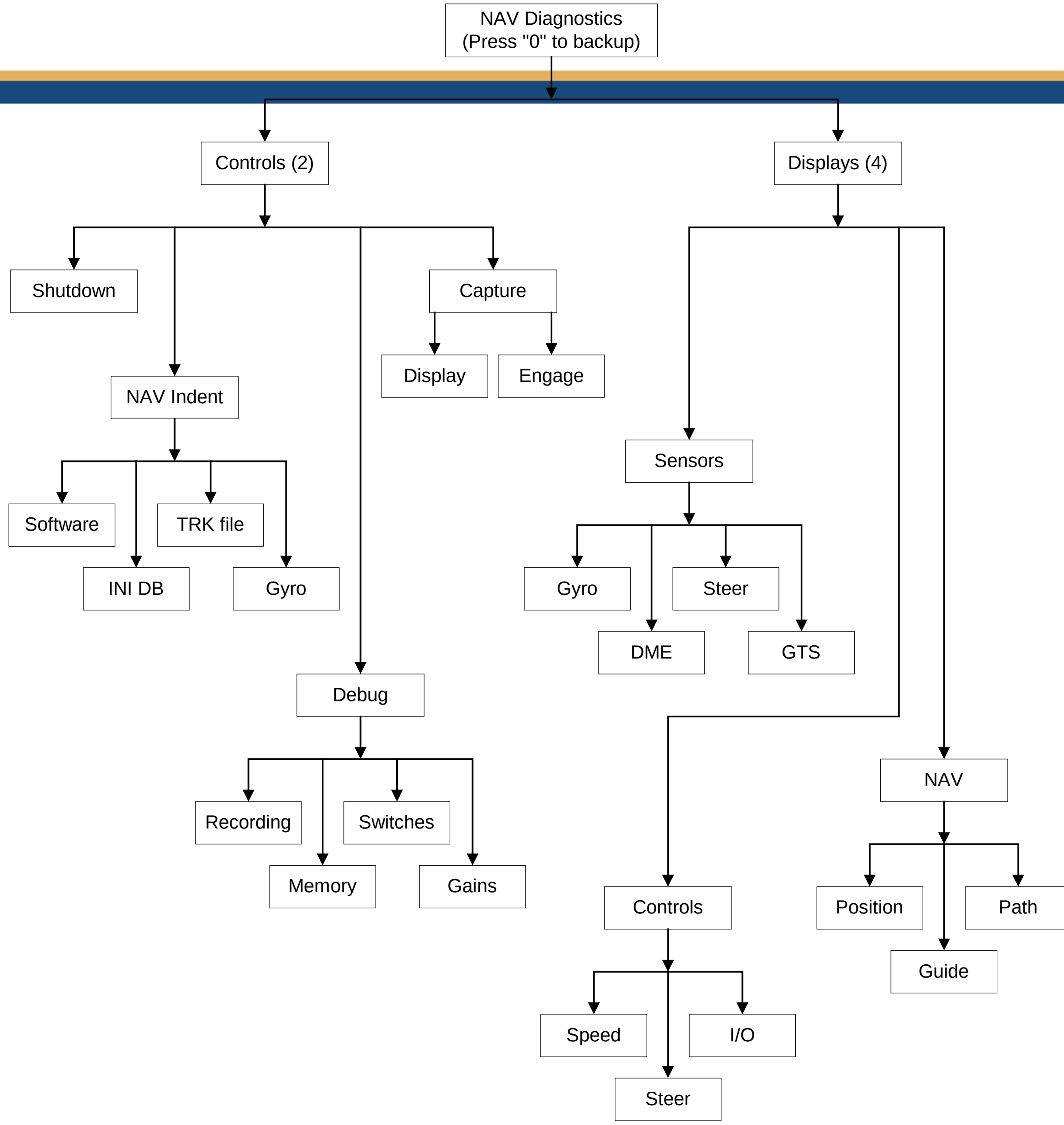
Softkeys: 1 or 2 4 6 8 or 9

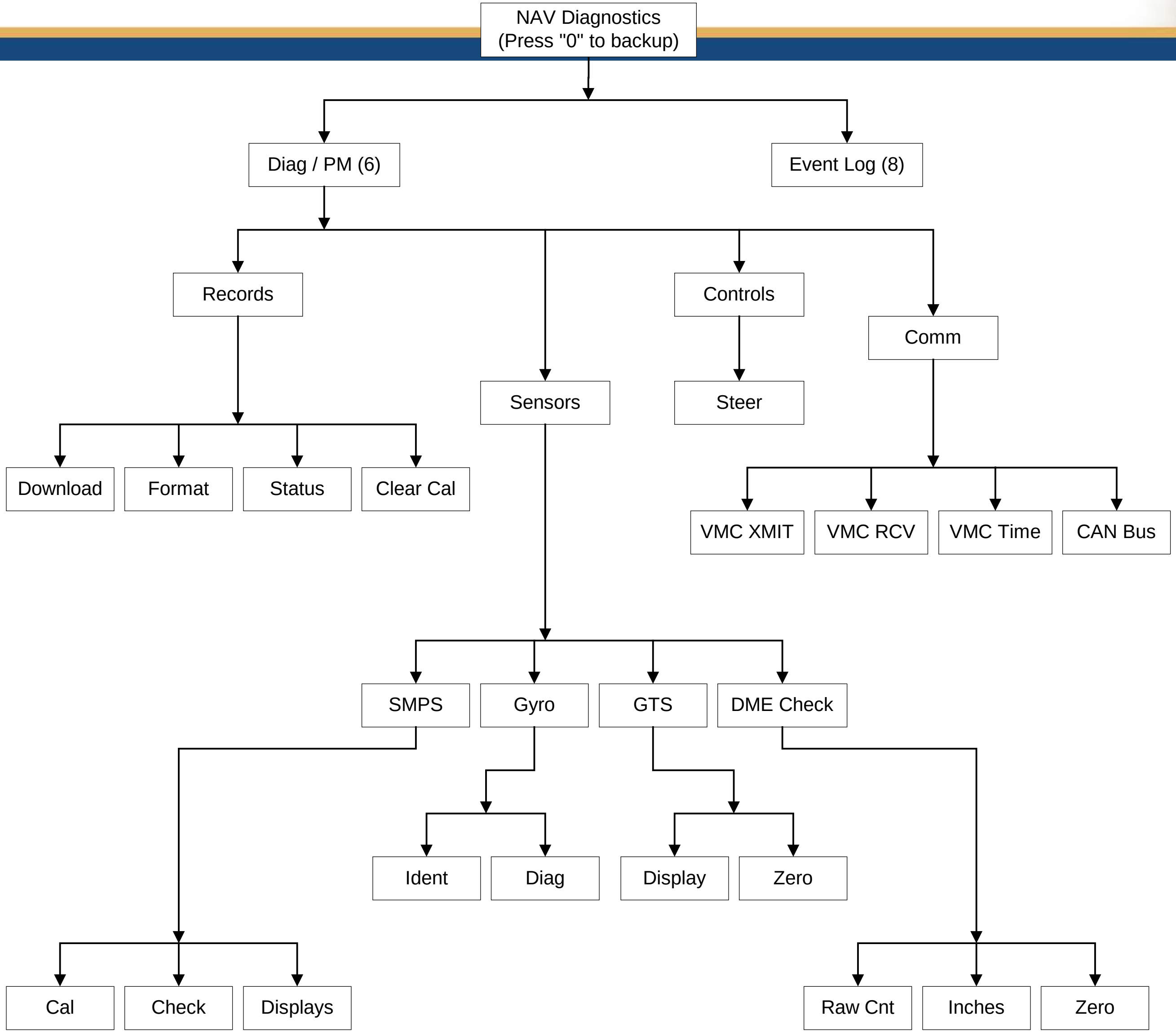
# CONTROL DISPLAY UNIT (CDU)




* See the Navigation Diagnostic Menu Tree (Figures 3 and 4)


NAV Diagnostics
(Press "0" to backup)
Controls (2)
Displays (4)
Shutdown
NAV Indent
Capture
Display
Engage
Software
TRK file
INI DB
Gyro
Debug
Recording
Switches
Memory
Gains
Sensors
Gyro
Steer
DME
GTS
NAV
Position
Path
Guide
Controls
Speed
I/O
Steer


NAV Diagnostics
(Press "0" to backup)
Diag / PM (6)
Event Log (8)
Records
Sensors
Controls
Comm
Steer
Download
Format
Status
Clear Cal
VMC XMIT
VMC RCV
VMC Time
CAN Bus
SMPS
Gyro
GTS
DME Check
Ident
Diag
Display
Zero
Cal
Check
Displays
Raw Cnt
Inches
Zero

# MAGNETS

- LOCATION AND HEADING ARE INITIALLY ESTIMATED FROM A PAIR OF INITIALIZATION MAGNETS WHEN THE VEHICLES ARE PLACED INTO THE SYSTEM.
- EACH IP LOCATION HAS A UNIQUE 2-DIGIT #. THE DISTANCE BETWEEN THE TWO MAGNETS DETERMINES THE IP #.
- MAGNETS ARE USED FOR UPDATING THE X,Y POSITION. THEY ARE USUALLY ARE PLACED 20 TO 30 FEET APART.
- EACH MAGNET HAS A UNIQUE X, Y COORDINATE LOCATION #, AS DETAILED ON THE GUIDE PATH LAYOUT. IF THE EXPECTED MAGNET IS NOT READ, VEHICLE WILL FAULT.
- EACH MAGNET IS IDENTIFIED BY UNIQUE 4-DIGIT #.
- THE MAGNETS ARE SURVEYED, SO EXACT POSITION IS LOCATED ON THE AUTO-CAD LAYOUT.

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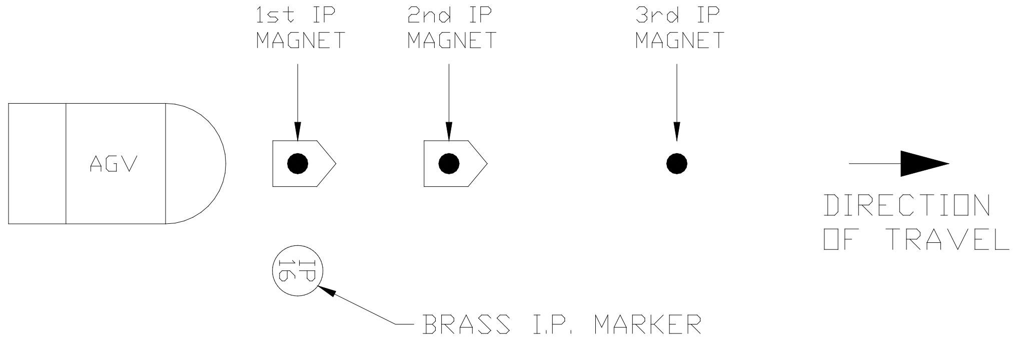
# *INITIALIZATION POINTS*

- ARE MAGNET LOCATIONS ON THE GUIDEPATH TO INITIALLY BRING THE VEHICLE INTO THE SYSTEM. x LOCATIONS ARE USED AT FORMET.
- EACH IP POINT IS MADE UP OF THREE MAGNETS; THE FIRST TWO ARE USED TO MANUALLY INITIALIZE THE AGV TO PUT IT ON THE PATH. THE THIRD MAGNET IS USED IN AUTOMATIC TO VERIFY THE AGV'S LOCATION.
- EACH IP POINT HAS A UNIQUE # AND IS DIFFERENTIATED BY A SPECIFIC DISTANCE BETWEEN THE TWO MAGNETS.
- THE INDIVIDUAL MAGNETS ARE IDENTIFIED BY A UNIQUE 4-DIGIT #. THE IP POINT NUMBER IS IDENTIFIED BY 1-8.



# WIRELESS NAVIGATON

- VIRTUAL PATH IS DRAWN IN AUTO-CAD AND EMBEDDED INTO THE NAVIGATION COMPUTER.
- NAVIGATION IS THE PROCESS OF DETERMINING THE AGV’S POSITION WITH RESPECT TO THE PLANT AT ANY POINT IN TIME.
- GYRO IS USED TO CALCULATE HEADING, RATE OF ROTATION AND POSITION WITH RESPECT TO THE PLANT.
- LOCATED AT THE CENTER OF THE VIRTUAL PATH ARE MAGNETS; WHICH ARE USED FOR X,Y UPDATES TO VERIFY THE VEHICLES CALCULATED POSITION.
- THE GTS (4th WHEEL) PROVIDES FURTHER ANGLE FEEDBACK AND DISTANCE TRAVELED (DME).

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# Wireless navigation (cont.)

- CURRENT X-Y POSITON & HEADING IS DETERMINED BY GYRO, GROUND TRACK SENSOR AND MAGNET SENSOR, WHICH ARE ALL NAVIGATION SENSORS.
- THE NAVIGATION SENSORS MEASURE THE BODY BASED CARTESIAN ROTATIONAL VELOCITIES.

  * VEHICLE BODY X VELOCITY.

  * VEHCILE BODY Y VELOCITY.

  *VEHCILE BODY ROTATION ROTATE.

# WIRELESS GUIDANCE

- GUIDANCE IS THE PROCESS OF CONTROLLING THE VEHICLE WITH RESPECT TO A GIVEN POINT ON THE VEHICLE ALONG THE VIRTUAL PATH.
- THE GUIDANCE SENSORS SPECIFICALLY MEASURE THE CONTROLS FEEDBACK.
- THE ELECTRICAL STEERING CONTROL IS ACCOMPLISHED USING STEER PCBS CONNECTED TO THE STEER (SERVO) MOTORS.
- THE ANGLE ENCODERS CONNECTED TO STEER MOTORS VIA CHAIN & SPROCKET DETERMINE THE REQUIRED STEER ANGLE TO GET BACK TO THE VIRTUAL PATH.

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# WIRELESS GUIDANCE (cont)

- NAVIGATION COMPUTER CONTROLS THE STEERING THROUGH THE STEER BOARDs AND STEER MOTOR; CONSTANTLY SEEKING ZERO TO KEEP THE VEHICLE ON THE VIRTUAL PATH.
- A STEER SIGNAL IS CREATED BASED ON A DISTANCE FROM A FIXED POINT ON THE VEHICLE AND SENT TO THE STEER BOARDs.
- PATH SELECTION DETERMINES WHICH PATH LAYER THE NAV. COMPUTER WILL USE TO FIND PATH SEGMENTS.
- WHEN AGV IS SIX INCHES AWAY FROM VIRTUAL PATH IT WILL SHUTDOWN (“OFFPATH” OR “NVPATH”).



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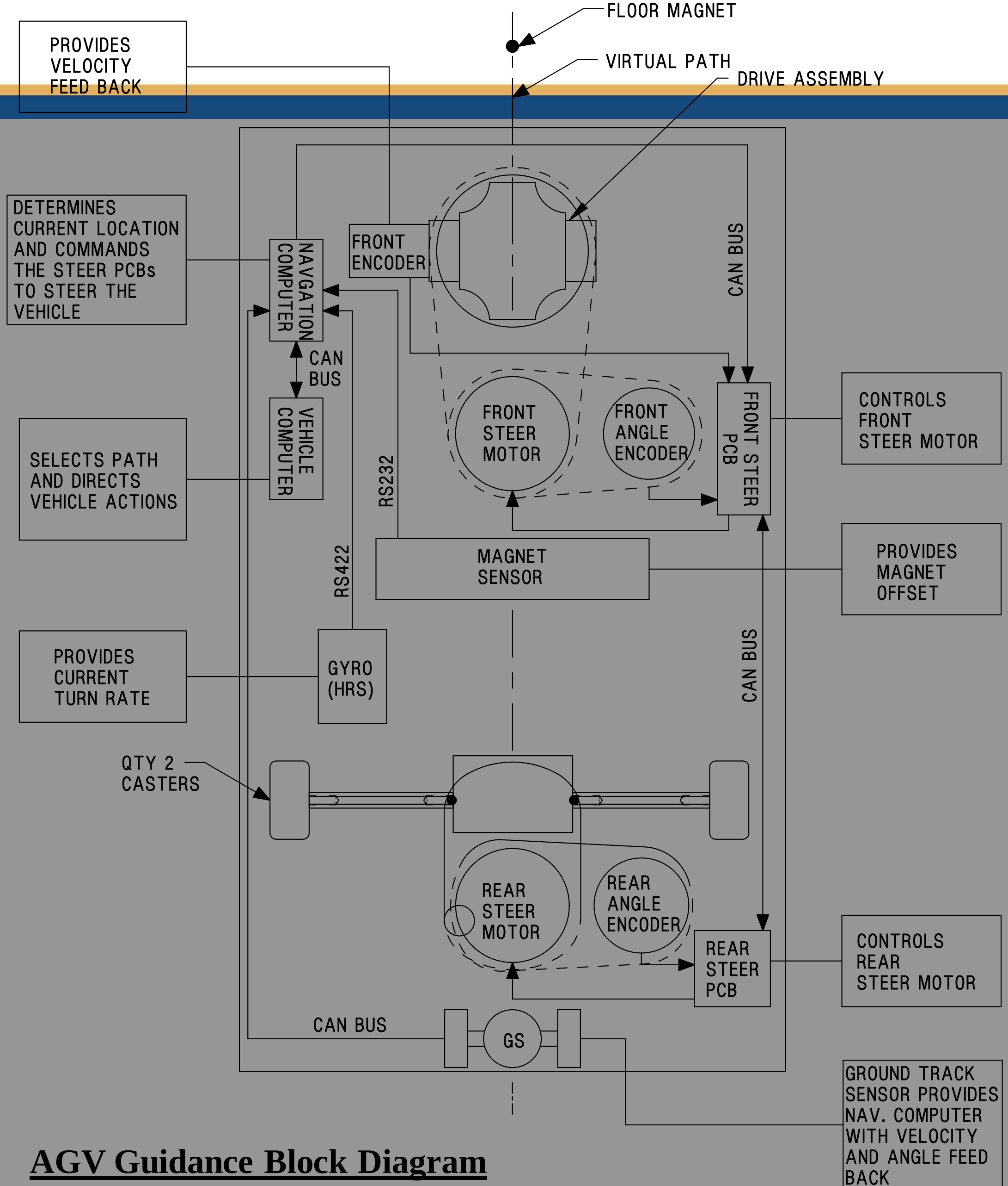


**AGV Guidance Block Diagram**

1000476D.CGM

# MAGNET POSITION SENSOR

- THE MAGNET POSITION SENSOR IS USED TO DETECT THE PRESENCE OF THE MAGNET AS THE AGV PASSES OVER IT. THE MAGNET PROVIDES A VERIFICATION OF THE AGV X,Y LOCATION ON THE VIRTUAL PATH.
- THE SENSOR USES AN ARRAY OF SENSORS TO DETECT THE PRESENCE OF A MAGNETIC FIELD. THE LATERAL POSITION IS CALCULATED DEPENDENT ON WHICH HALL EFFECT SENSORS DETECTED THE HIGHEST LEVELS.
- THE LATERAL POSITION IS THEN SENT TO THE NAVIGATION COMPUTER. THE COMPUTER THEN COMPARES THE COMPUTED POSITION WITH THE STORED POSITION AND LATERAL STEERING CORRECTIONS ARE MADE TO KEEP THE VEHICLE ON THE PATH.
- SENSOR COMMUNICATES TO NAV. COMPUTER VIA RS232 LINK.
- THE LATERAL POSITION AND MAGNET ID CAN BE DISPLAYED ON DISPLAY DIAGNSOTIC SCREEN. SEE P. 28-35 IN TROUBLESHOOTING.



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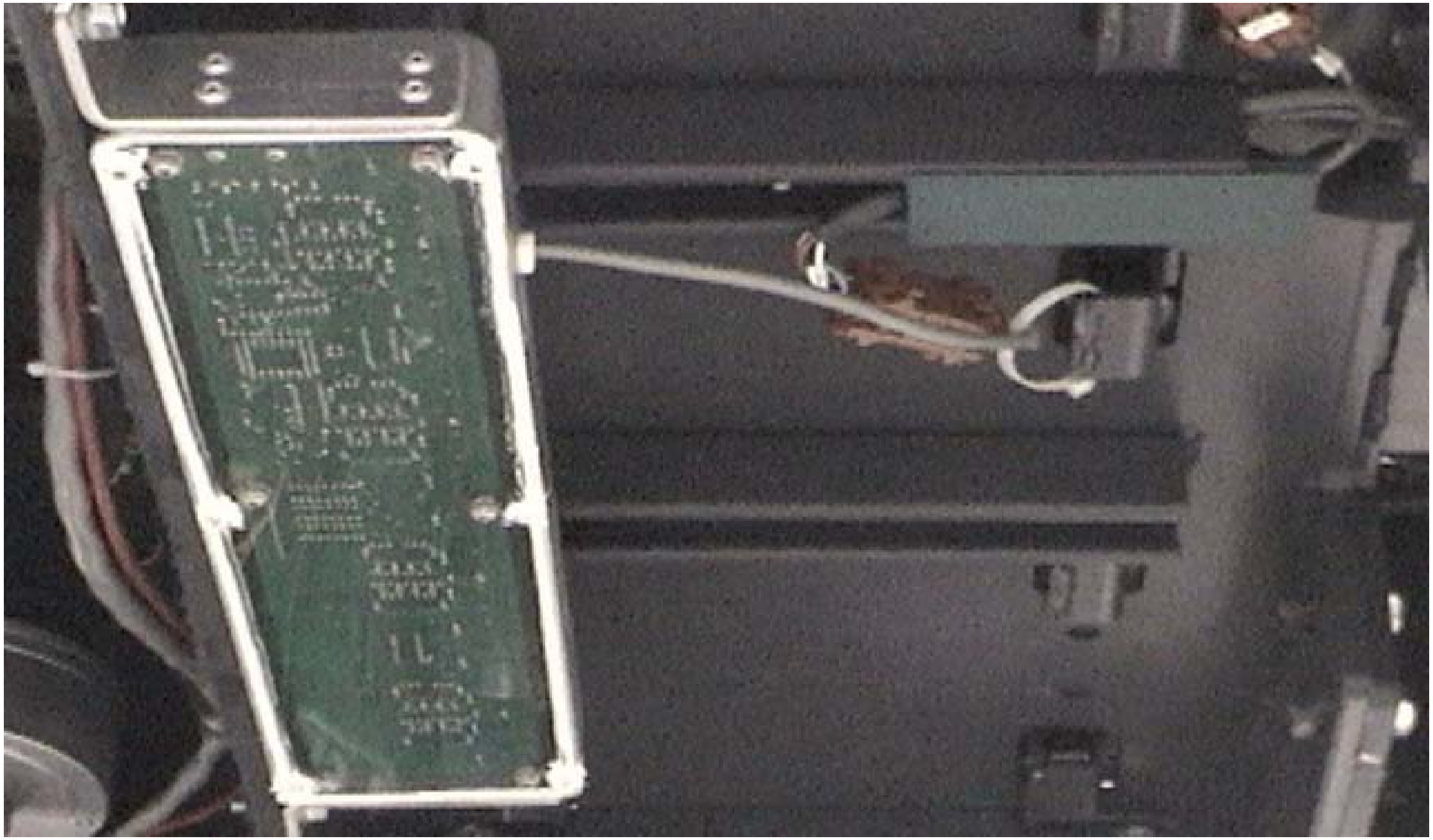
# Magnet Sensor

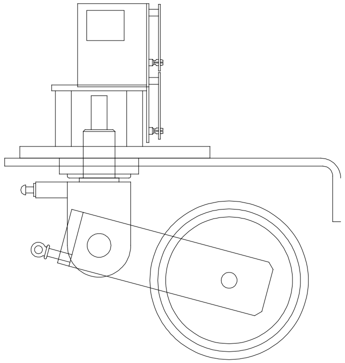


# GYRO (HRS)

- THE GYRO IS A NAVIGATION SENSOR.
- CALCULATES THE RATE OF ROTATION (HEADING) AND VEHICLE'S CURRENT X,Y POSITION WITH RESPECT TO THE PLANT WHICH IS REFERENCED TO THE EMBEDDED AUTO-CAD MAP.
- THE GYRO AND GTS ARE TIGHTLY COUPLED TOGETHER. THE ROTATION RATE AND THE GTS ODOMETRY MEASURE THE RELATIVE MOVEMENT, WHICH IS THE FORWARD DISTANCE AND SIDE SLIP.
- CONNECTED TO THE NAVIGATION COMPUTER VIA AN RS422 Serial Link.
- NAV DIAGNOSTIC SCREENS ON THE AGV DISPLAY PROVIDE GYRO INFORMATION FOR TROUBLESHOOTING.
- SEE P. 41-43 IN TROUBLESHOOTING

# GROUND TRACK SENSOR

- THE GROUND TRACK SENSOR (4TH WHEEL) IS A NON LOAD BEARING SWIVEL CASTER MOUNTED TOWARDS THE REAR OF THE VEHICLE.
- IT PROVIDES DISTANCE TRAVELED INFORMATION (DME ENCODER) TO THE NAVIGATION COMPUTER. IT IS THE PRIMARY NAVIGATIONAL ODOMETRY.
- IT PROVIDES ANOTHER ANGLE FEEDBACK (Absolute Encoder) TO THE NAVIGATION COMPUTER WITH A 360º ROTATION.
- IT IS USED AS ANOTHER PERIODIC UPDATE TO CORRECT FOR DRIFT AND SIDE SLIP.
- INFORMATION CAN BE DISPLAYED ON THE DISPLAY NAV. DIAGNOSTIC SCREEN. SEE P.38-41 IN TROUBLESHOOTING.
- THE GROUND TRACK SENSOR DATA IS SENT TO THE NAV. COMPUTER VIA THE CAN BUS NETWORK.





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# AGV COMPUTERS

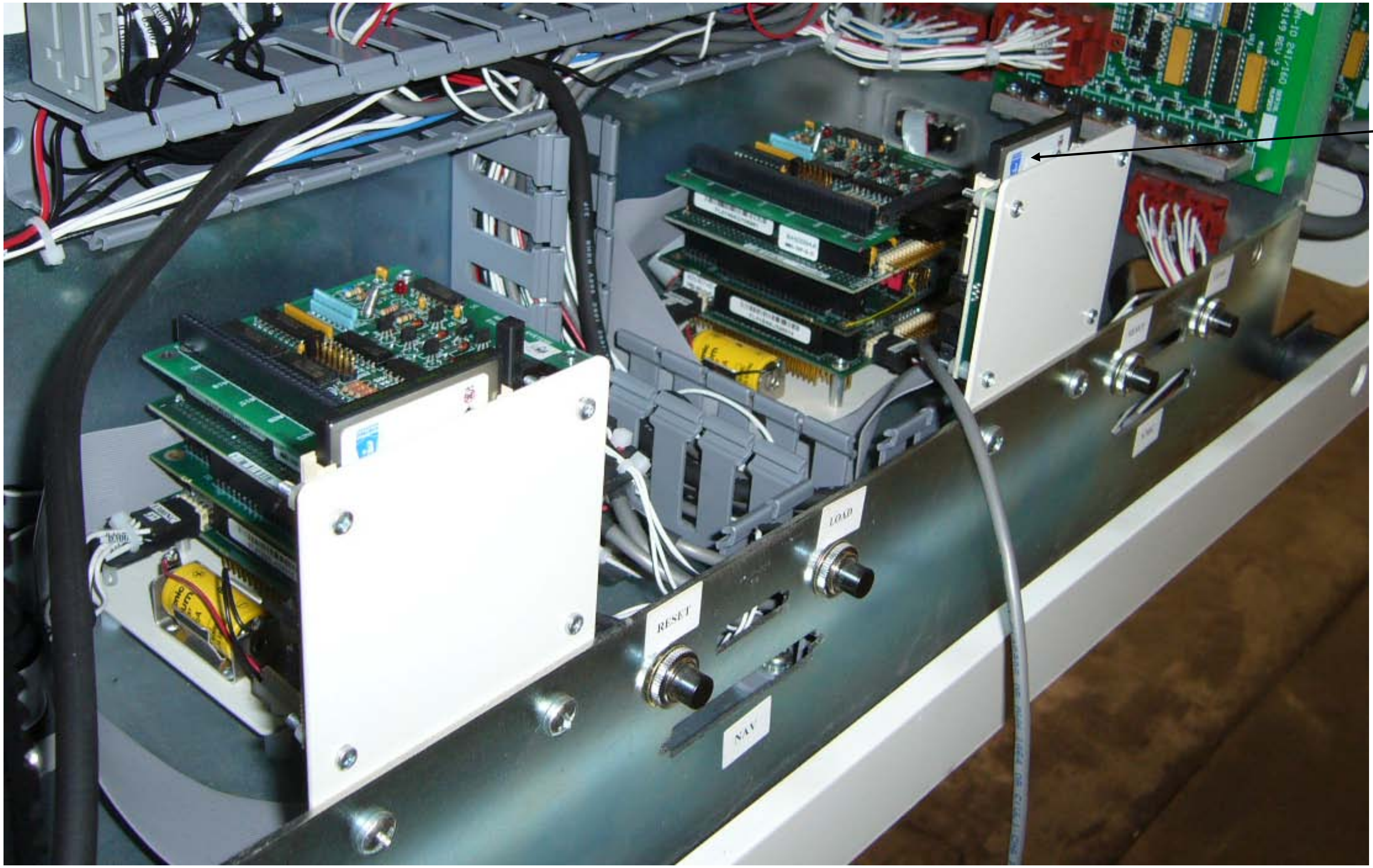
**NAVIGATION COMPUTER(NC)** IS USED TO GUIDE THE VEHICLE AND DETERMINE THE VEHICLE'S LOCATION.

**VEHICLE MICROCOMPUTER (VMC)** IS USED TO CONTROL THE VEHICLE FUNCTIONS SUCH AS SPEED, INPUTS & OUTPUTS, START/STOP,ROUTING (PATH SELECTION) AND TRAFFIC CONTROL VIA RF COMMUNICATIONS.

THE TWO COMPUTERS COMMUNICATE WITH EACH OTHER VIA THE CAN BUS NETWORK.

NAVIGATION COMPUTER TRANSMITS VIRTUAL CODE # TO VEHICLE COMPUTER FOR VEHICLE CONTROL AND TRAFFIC CONTROL..

# Computers




Compact Flash

NAV

Vehicle MicroComputer (VMC)

# CAN BUS Communications

- The **C**ontroller **A**rea **N**etwork BUS is used for data communications between sub-system microprocessors. A simple two wire twisted pair cable is used to interconnect all the devices. The network uses a specific protocol for transmission and error detection.
- Electrically it uses a differential drive, which makes it immune to higher noise environments.
- Each sub-system has its own processor with a specific ID address. The processor also determines the frequency at which the data will be transmitted. All the sub-systems operate at 120K baud rate.
- All sub-systems continually transmit to the BUS at that baud rate, but filtering is utilized to not listen to certain sub-systems.

# Can bus (continued)

- NAVIGATION COMPUTER:

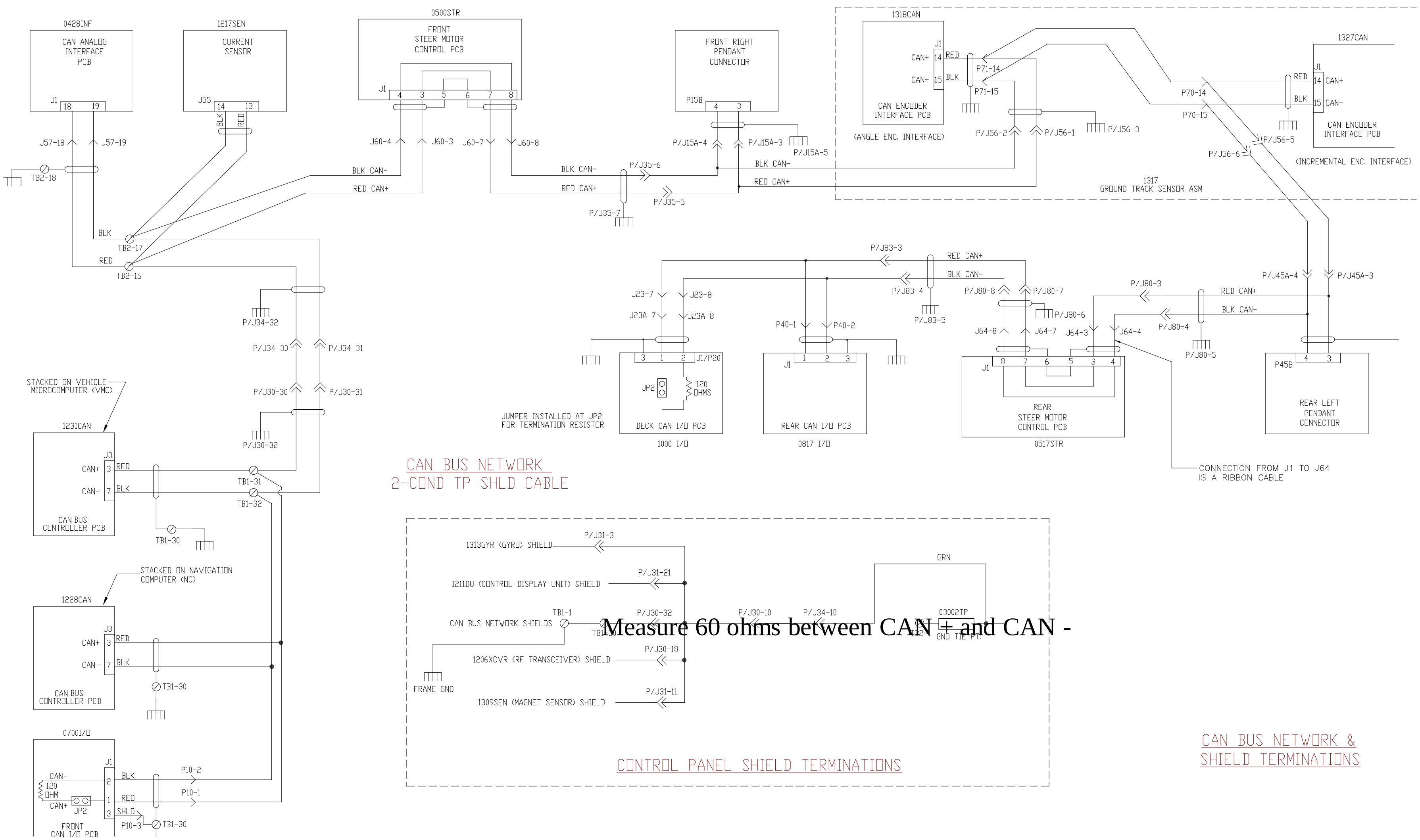
  * Listens to VMC, Steer Control Boards, and Ground Track Sensor. Note: Communications to Gyro and Magnet Sensor is via RS422 and RS232.
- VEHICLE COMPUTER:

  * Listens to NAV Computer, CAN I/O PCBS, Front Steer PCB, and Battery Monitor Sensor.
- FRONT/REAR STEER PCBS:

  * Listens to Navigation Computer, Vehicle Micro Computer, and Pendant.
- CAN ANALOG PCB (Drive):

  * Listens to Vehicle Computer, Pendant, and Front Steer PCB.
- BATTERYMONITOR SENSOR >>>>>> VEHICLE COMPUTER
- QTY 3 CAN I/O PCBs >>>>>>>>VEHICLE COMPUTER.

# CAN Bus Block Diagram




Measure 60 ohms between CAN + and CAN -

# STEER CONTROL

- THE NAVIGATION COMPUTER SENDS STEER COMMANDS TO STEER CONTROL PCBS via the CAN BUS. IT COMMANDS IT TO A SPECIFIED ANGLE. CENTER WILL ALWAYS be Angle “0”.
- THE STEER CONTROL PCB CONTROLS THE CURRENT/VOLTAGE TO THE SERVO MOTORS.
- THE AGV CONSTANTLY STEERS TO KEEP ITS NAVIGATION POINT AND THE VIRTUAL WIRE CLOSE TO ZERO ON A STRAIGHT PATH.
- THE NAVIGATION CONTROL POINTS ON THE DC60 AGV ARE:
  - FRONT – CENTER OF DRIVE TIRE
  - REAR – BETWEEN TO REAR CASTERS (CENTER).

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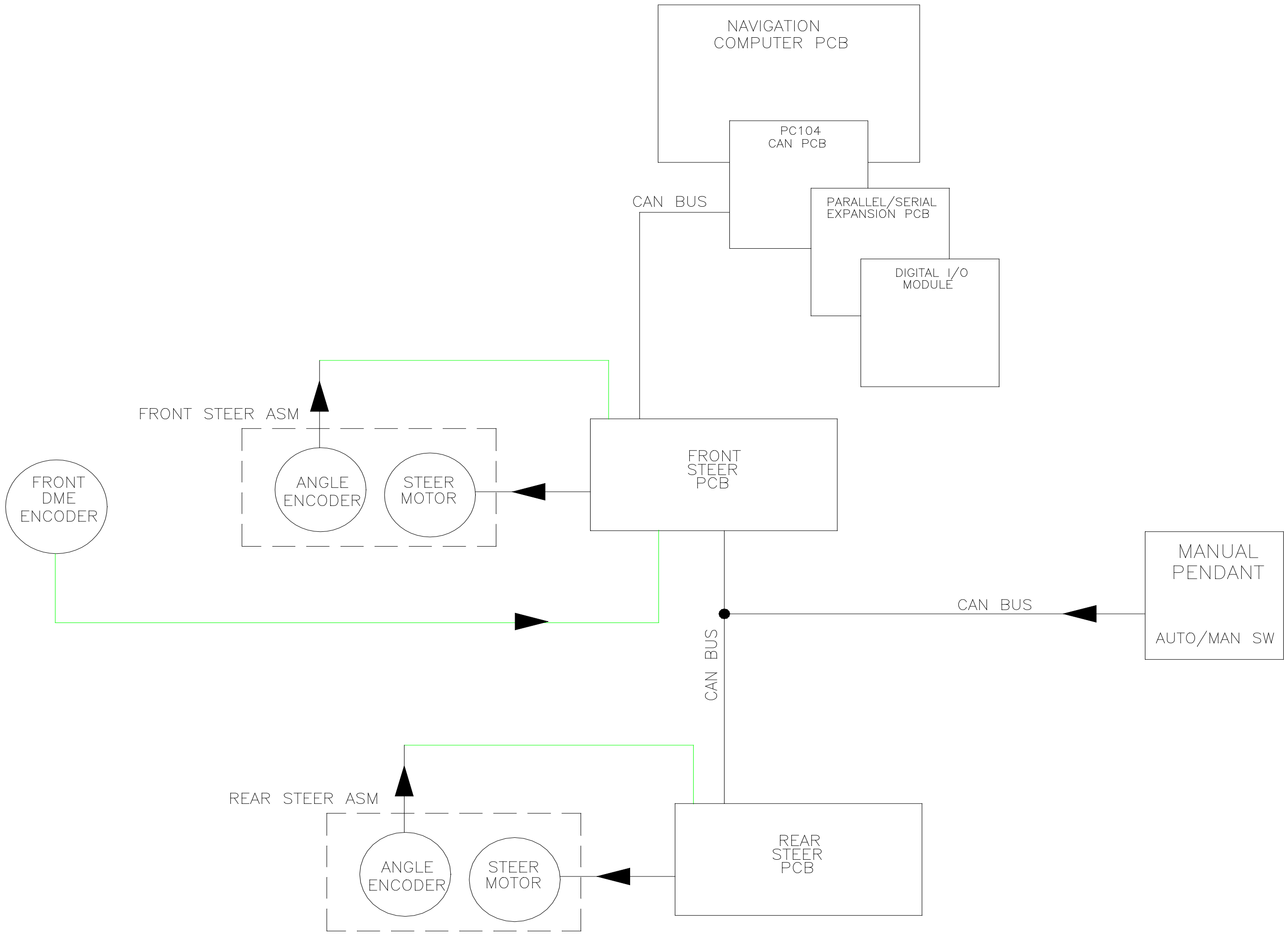
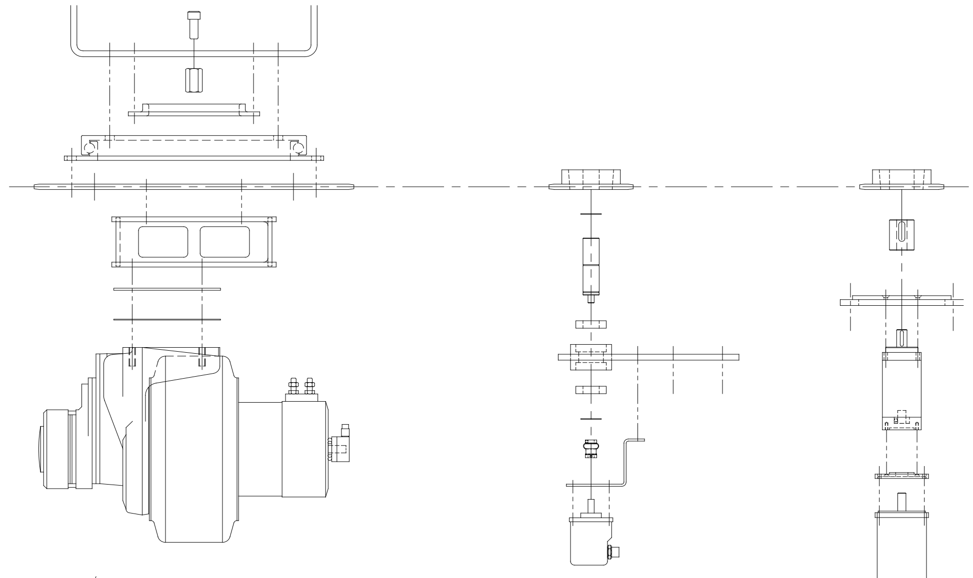
# STEER CONTROL (CONT)

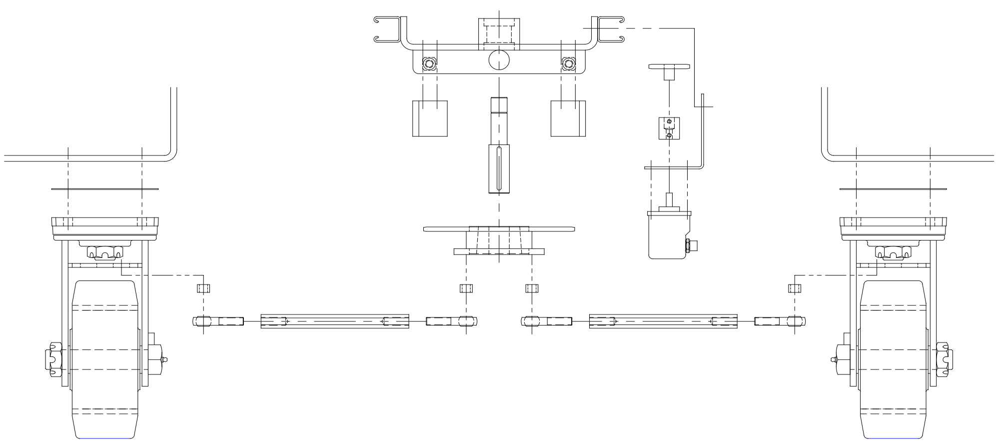
- AN ANGLE ENCODER MOUNTED TO THE FRONT/REAR STEER MOTORS ARE USED FOR ANGLE FEEDBACK. THE ANGLE ENCODERS ARE CONNECTED TO STEER PCBS AND THE ANGLE DATA IS THEN SENT TO THE NAVIGATION COMPUTER VIA THE CAN BUS.
- THE FRONT AND REAR STEER CONTROL ARE ELECTRONICALLY LINKED. THE REAR STEER PCB FOLLOWS THE FORWARD HEADING PCB, BUT WITH THE OPPOSITE EQUAL ANGLE IN NORMAL MODE. IN “CRAB” MODE THE ANGLES ARE THE SAME.
- IN MANUAL MODE, THE COMMANDS COME FROM THE PENDANT AND ARE IDENTICAL TO NAV. COMPUTER COMMANDS.
- THE FRONT/REAR STEERING COMPONENTS ARE CALIBRATED.
- IF THE NAV. COMPUTER COMMANDED ANGLE IS NOT OBTAINED WITHIN A TIME FRAME, A STEER FAULT WILL OCCUR.
- IF VEHICLE IS DOG TRACKING, VERIFY STEER ADJUSTMENTS.
- STEER PCBS WILL NOT OUTPUT A STEER SIGNAL, UNLESS THE AGV IS SLIGHTLY MOVING. USES FRONT DME ENCODER COUNTS. SEE P. 36-37 IN TROUBLESHOOTING.




# DC60 STEER CONTROL



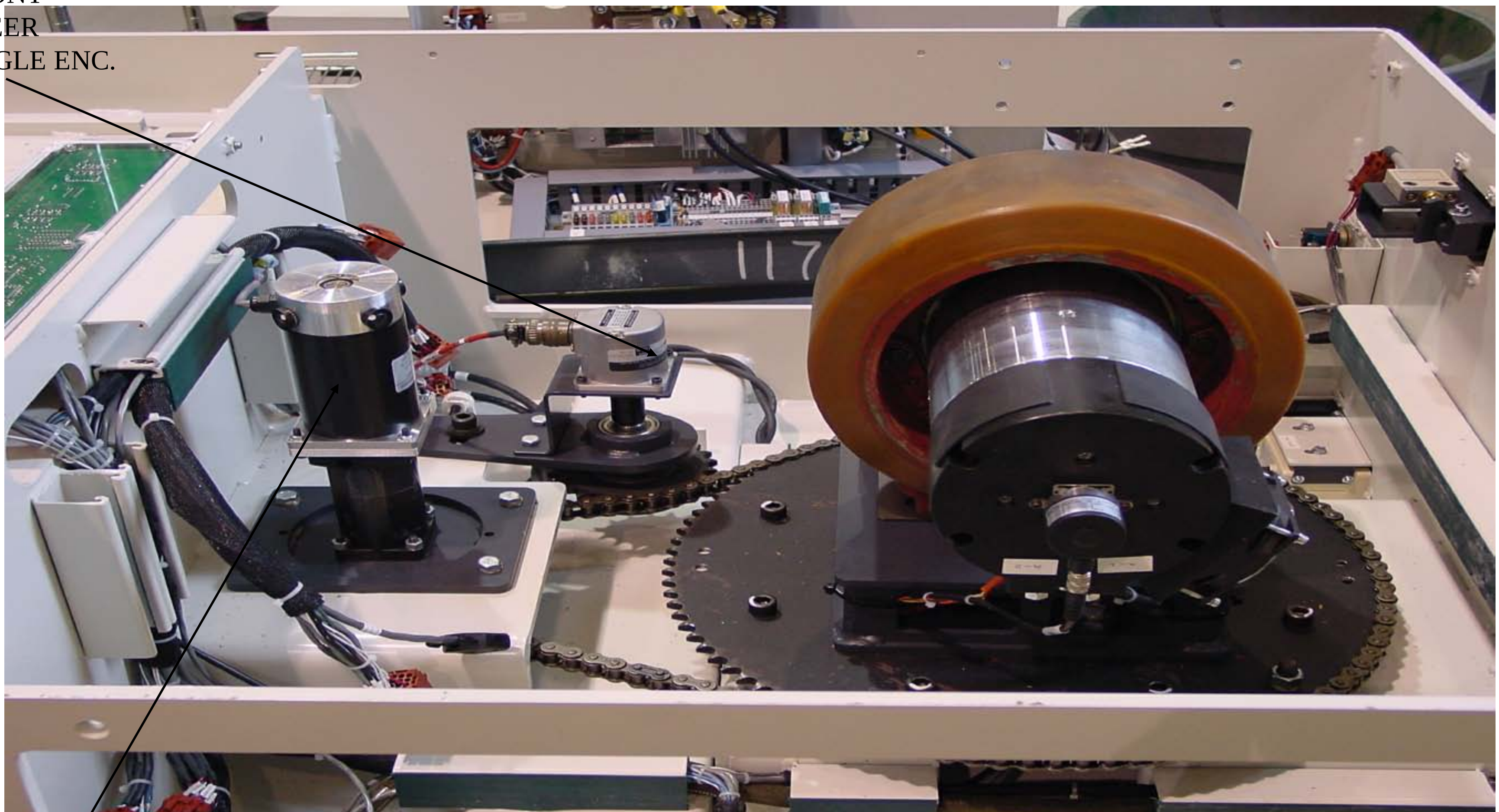
FRONT DRIVE/STEERING ASM



REAR CASTER/STEERING ASM

# FRONT STEERING COMPONENTS

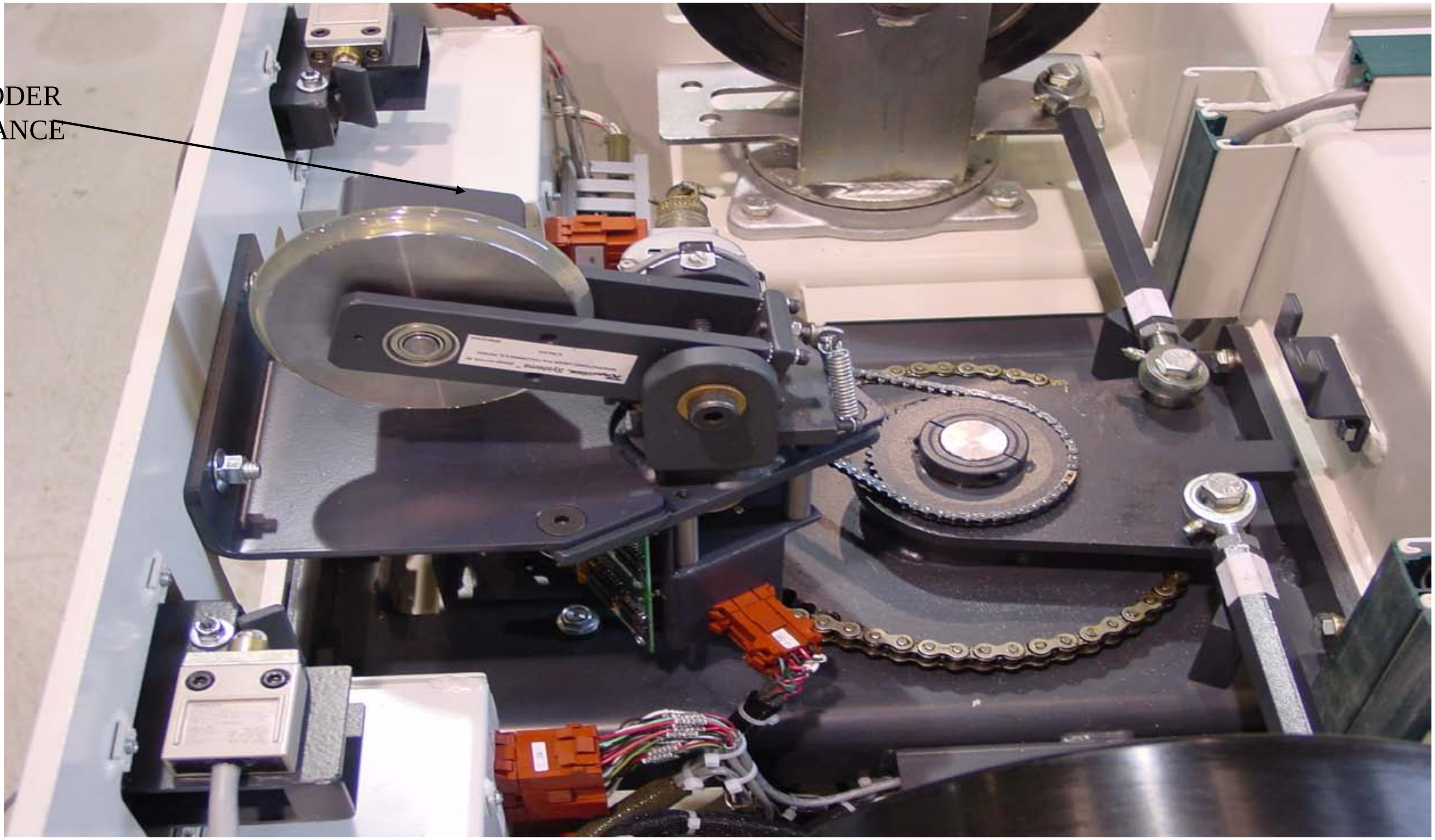
FRONT
STEER
ANGLE ENC.



FRONT
STEER
MOTOR

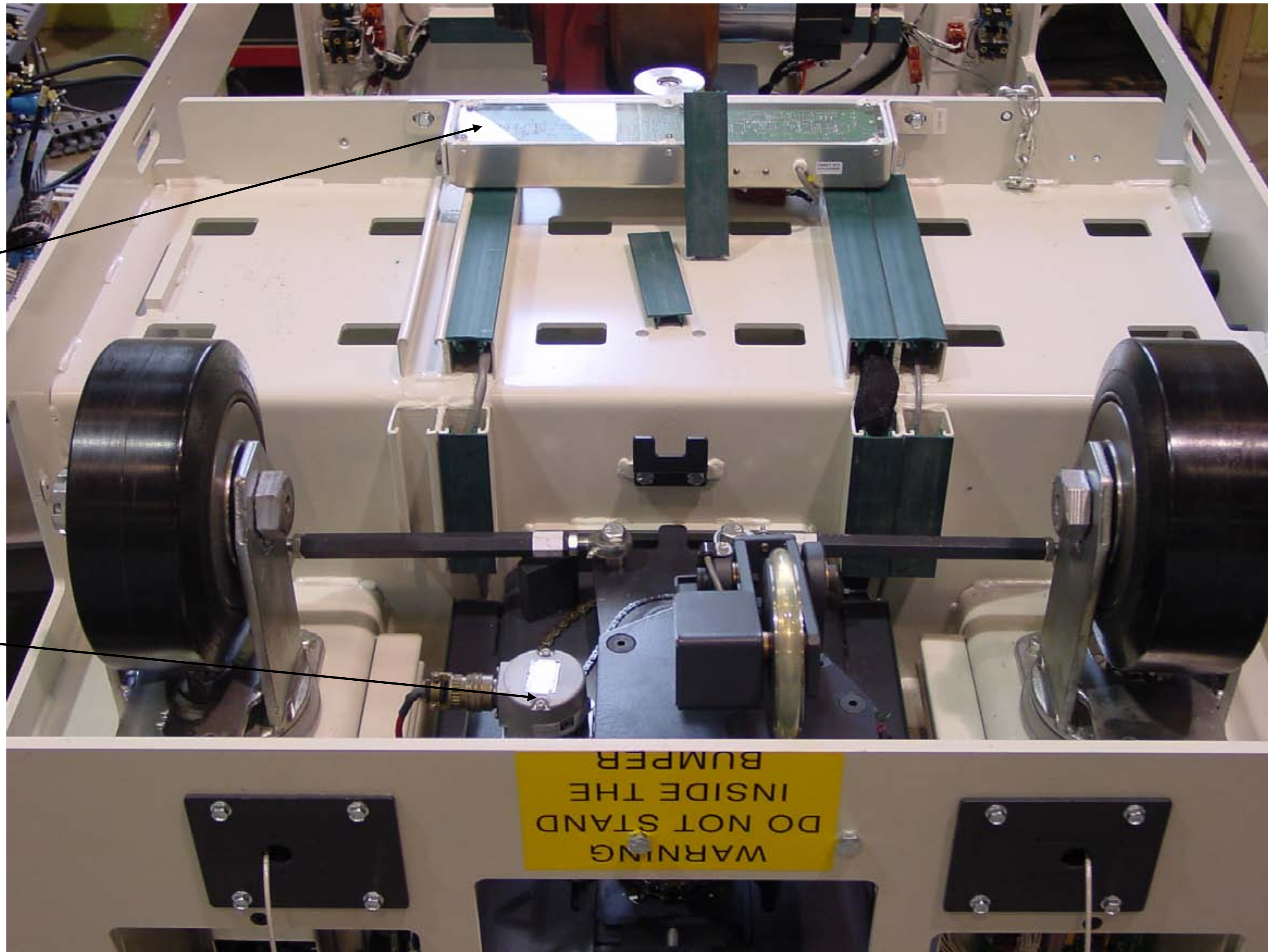
# GROUND TRACK SENSOR AND REAR STEERING

GTS
ENCODER
DISTANCE



# REAR STEERING AND MAGNET SENSOR

Magnet
Sensor




REAR
STEER
ANGLE
ENCODER

# DRIVE CONTROL

- A Zahn Servo Amplifier is used to drive the motor/assembly connected to the front drive wheel. The amplifier uses PWM of the supply voltage to control the speed.
- Speed Commands from the Vehicle Computer are sent to an Analog Interface PCB via the CAN Bus. The Analog Interface PCB outputs a DC voltage to the Servo-AMP.
- Velocity feedback is also sent to the Vehicle Computer and the Analog Interface PCB by an encoder that is mounted to the front drive assembly. The encoder is connected to the front steer PCB and the encoder data is relayed over the CAN Bus Network.
- CEMF is used to provide velocity feedback to the Servo Amps (Coarse Feedback).
- The Analog Interface PCB will also close the feedback loop to keep the vehicle speed constant (Fine controlled feedback).

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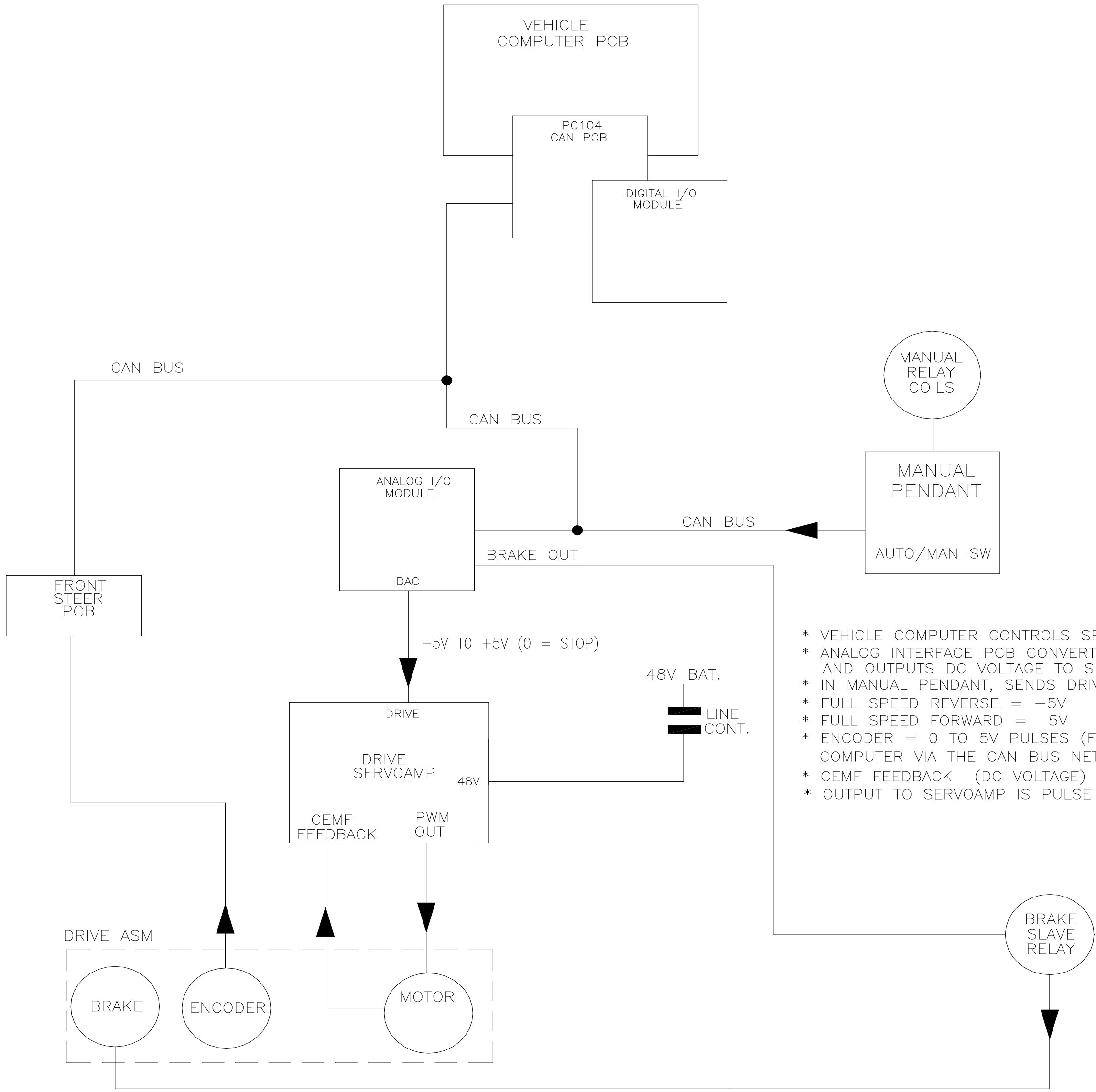
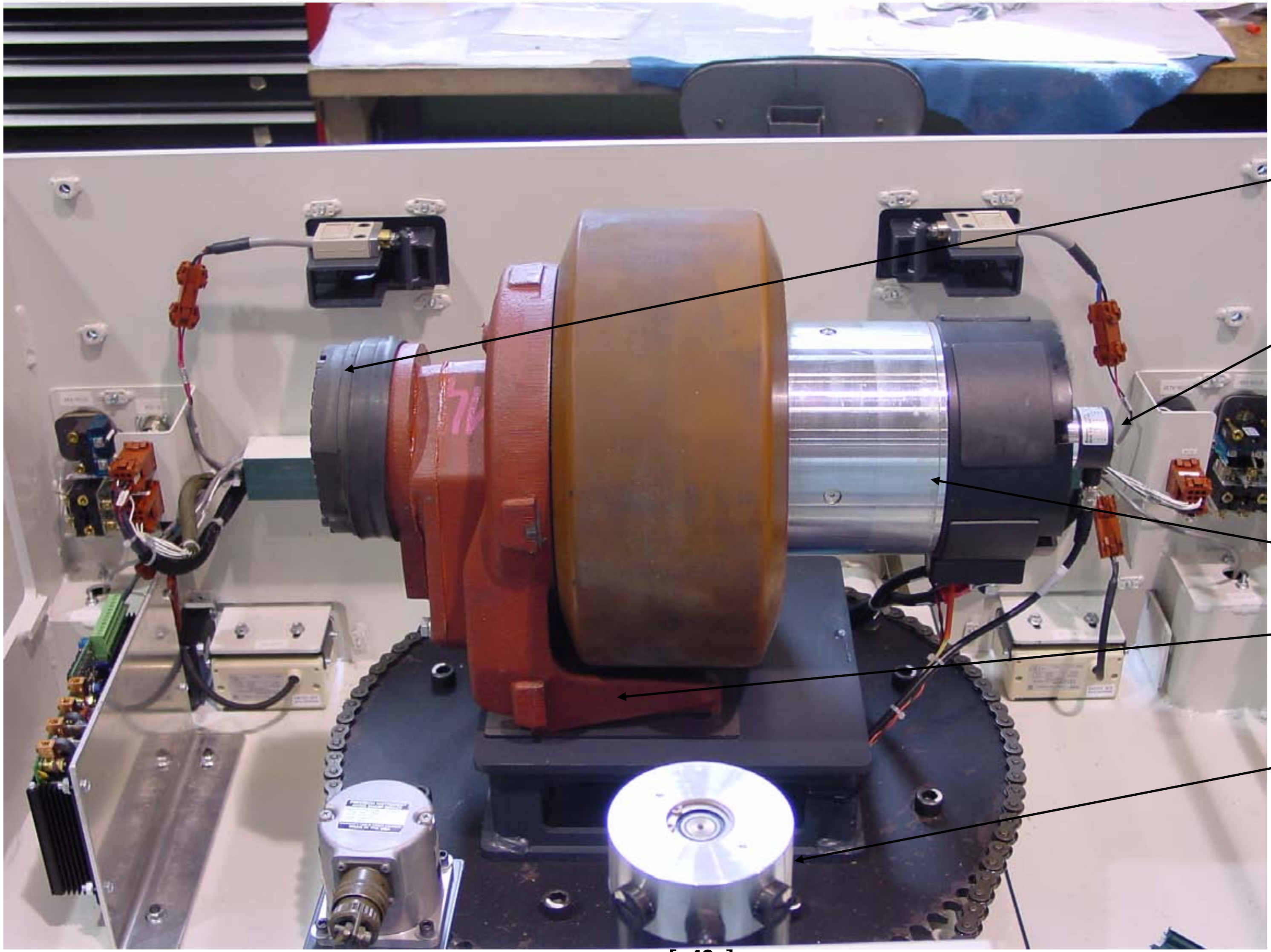


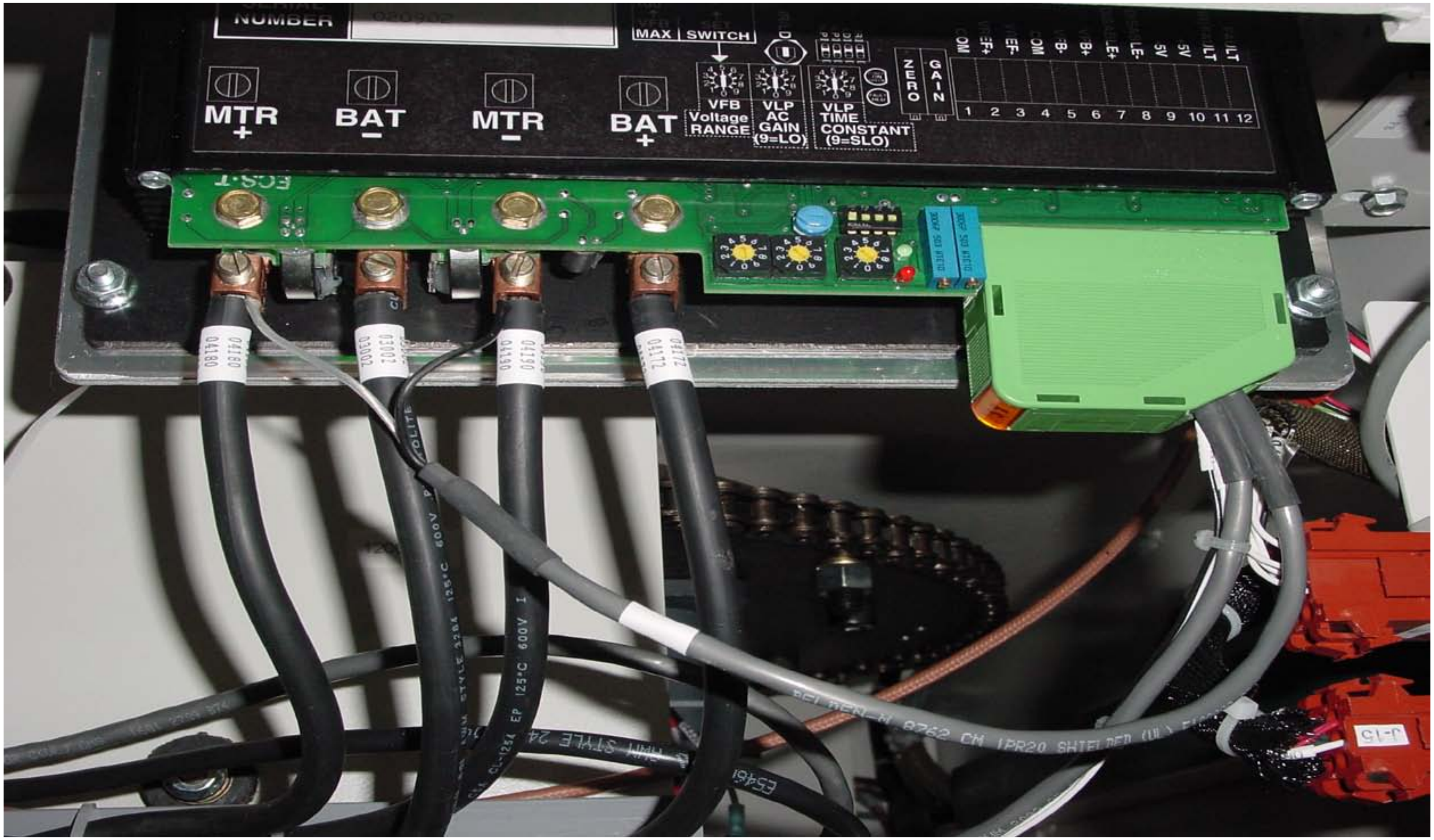

* VEHICLE COMPUTER CONTROLS SPEED VIA CAN BUS COMMAND TO ANALOG I/O PCB.
* ANALOG INTERFACE PCB CONVERTS DATA TO ANALOG VOLTAGE AND OUTPUTS DC VOLTAGE TO SERVOAMP BOTH IN AUTO AND MANUAL MODE.
* IN MANUAL PENDANT, SENDS DRIVE DATA TO ANALOG PCB VIA CAN BUS.
* FULL SPEED REVERSE = -5V
* FULL SPEED FORWARD = 5V
* ENCODER = 0 TO 5V PULSES (FEED BACK) TO FRONT STEER PCB. COMPUTER VIA THE CAN BUS NETWORK.
* CEMF FEEDBACK (DC VOLTAGE) TO SERVOAMP.
* OUTPUT TO SERVOAMP IS PULSE WIDTH MODULATED (0 TO 48 VOLTS).

# DC30 DRIVE CONTROL BLOCK DIAGRAM

# DRIVE ASSEMBLY –IN WHEEL DRIVE (DRIVE,MOTOR,BRAKE.ENCODER, TURNTABLE

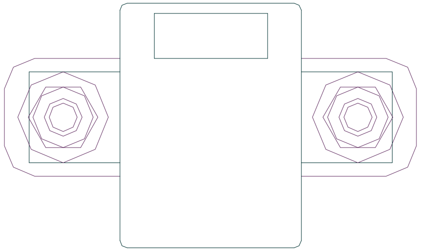


# DRIVE CONTROLLER (SERVOAMP)

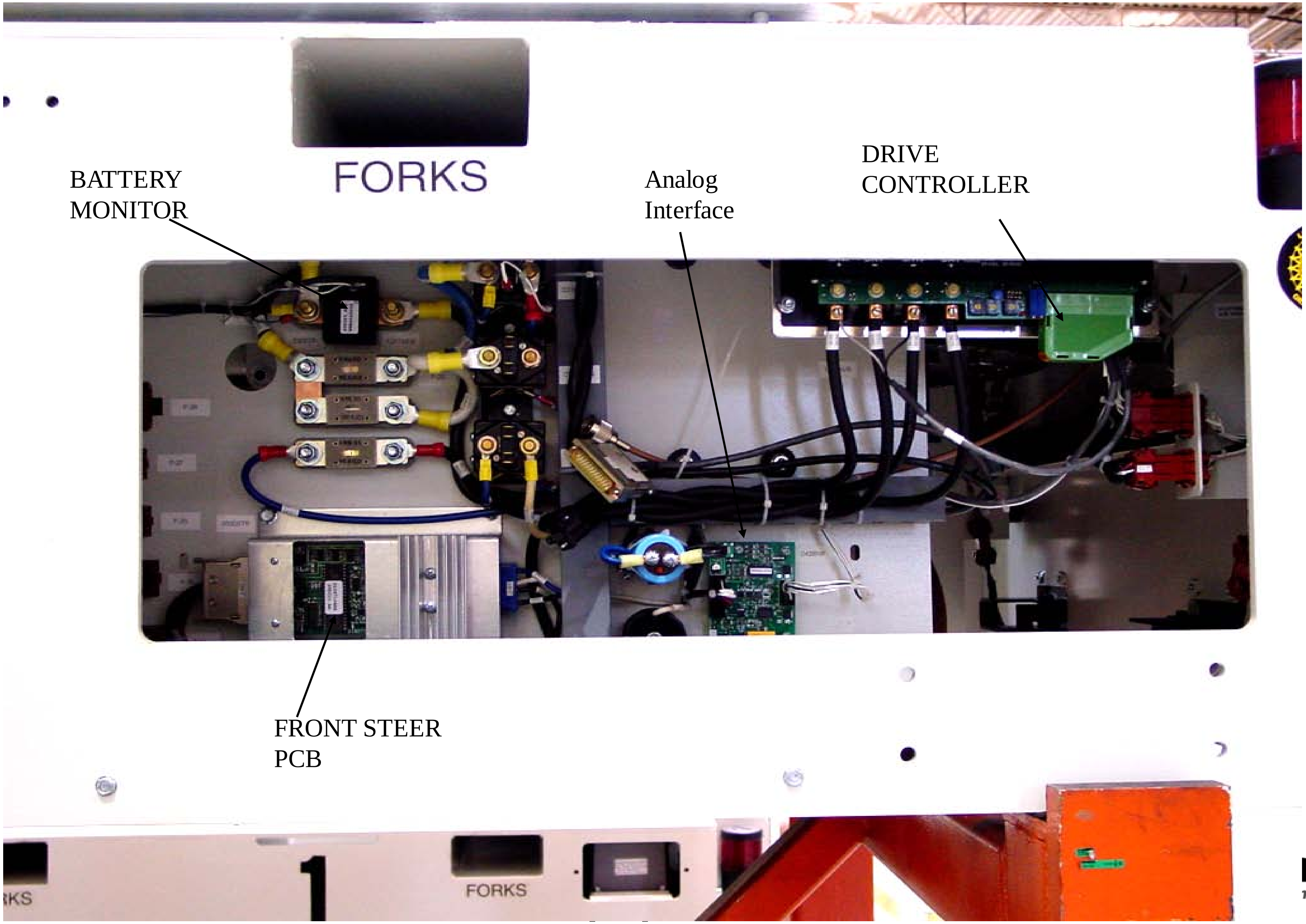


# *BATTERY MONITOR SENSOR*

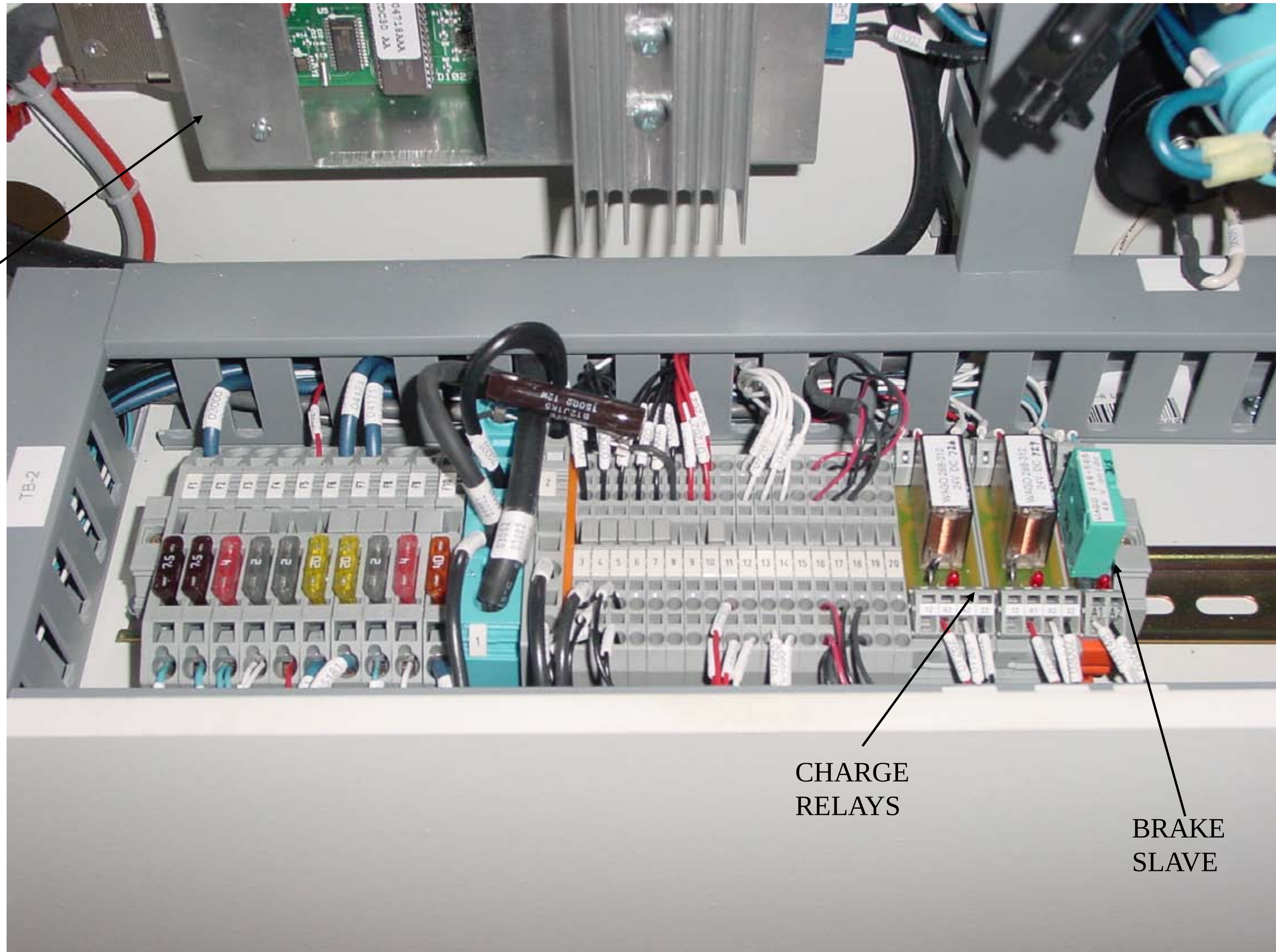
- **THE SENSOR IS USED TO MONITOR THE BATTERY VOLTAGE AND CURRENT.**
- **THE VEHICLE MICRO COMPUTER VIA THE CAN BUS USES THE SENSOR'S DATA TO DISPLAY THE BATTERY LEVEL. A "9" DENOTES A FULLY CHARGED BATTERY. A "0" DENOTES AN 80% DISCHARGED BATTERY. THE AGV SHOULD NOT BE OPERATED WHEN THE LEVEL IS AT "0".**
- **THE CURRENT FLOW IS ALSO DETECTED AND USED FOR THE OPPORTUNITY CHARGE CYCLE IF USED.**
- **IF THE BATTERY LEVEL DECREASES TO LEVEL "0"; THE VMS Computer WILL DISPATCH THE AGV TO THE Manual Battery Station.**
- **THE SENSOR IS MOUNTED ON A GROUND BUSS BAR LOCATED IN THE POWER PANEL ASSEMBLY.**



# POWER PANEL ASSEMBLY

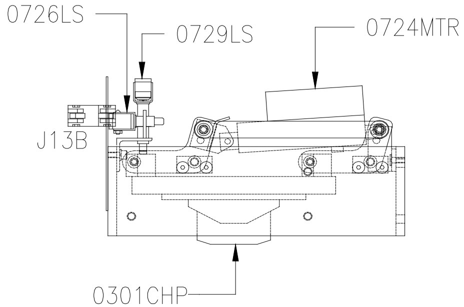


# Power PANEL ASSEMBLY (FRONT STEER PCB, CHARGE RELAYS,BRAKE SLAVE RELAY, FUSES)



# Opportunity Charge

- At charge station: vehicle reads virtual code, slows to creep speed, accurate stops over floor mounted charge plate. Linear actuator is energized to lower charge plates. At the lower limit charge contr. is energized to apply 48v across charge shoes. If lower or upper limit is not sensed a charging error (408) will occur.
- Charger senses 48v across floor plates and energizes.
- Vehicle battery monitor sensor senses opposite current flow. Data is routed to vehicle micro computer. IF CURRENT FLOW IS NOT DETECTED, CYCLE IS ABORTED AND CHARGE ERROR IS DISPLAYED (409 error). If battery level is at 7, 8, or 9; error not displayed.
- When no more negative current is sensed, contactor opens. At level 6, contactor energizes again.
- The battery supplier RECOMMNEDS that the batteries are equalized every 100 hours. Use manual charge station for equalization.



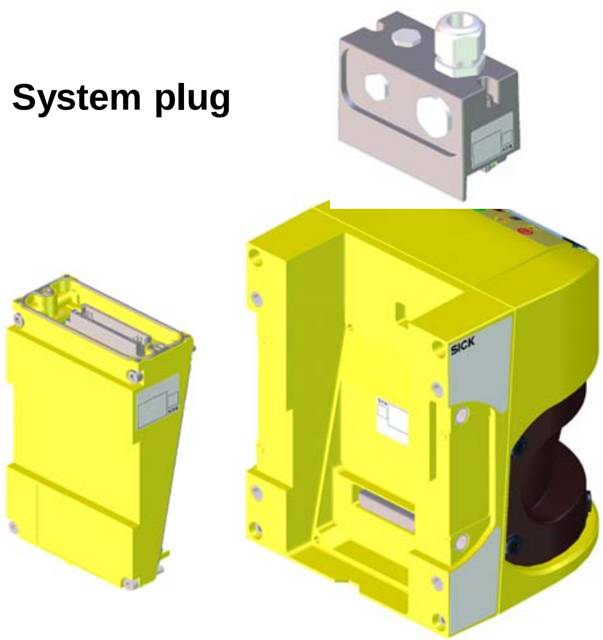

OPPORTUNITY CHARGE ASM.

# Laser Scanner Bumpers

- **The DT60 uses proximity laser scanner bumpers for collision protection. The scanners are programmed to detect objects in the guidepath area. The scanners utilize two protection zones, the long range warning field zone slows the vehicle to a reduced speed and the short range detection zone emergency stops the AGV by immediately setting the brake. The warning/detection profiles are configured to vary with the AGV's speed.  As the speed of the AGV increases, the range of each zone will increase.**
- **If the front system plug laser scanner is replaced, the Siemens specified configuration file has to be installed using SICK's application software. The procedure is covered in the repairs chapter of the maintenance manual.**

# Laser Scanner Components

- The front mounted scanner will use the professional I/O module and the rear mounted scanner will use the remote I/O module.
- The front mounted scanner will utilize the system plug with the configuration file and control the safety relay. The professional module communicates to the remote module via a network cable.

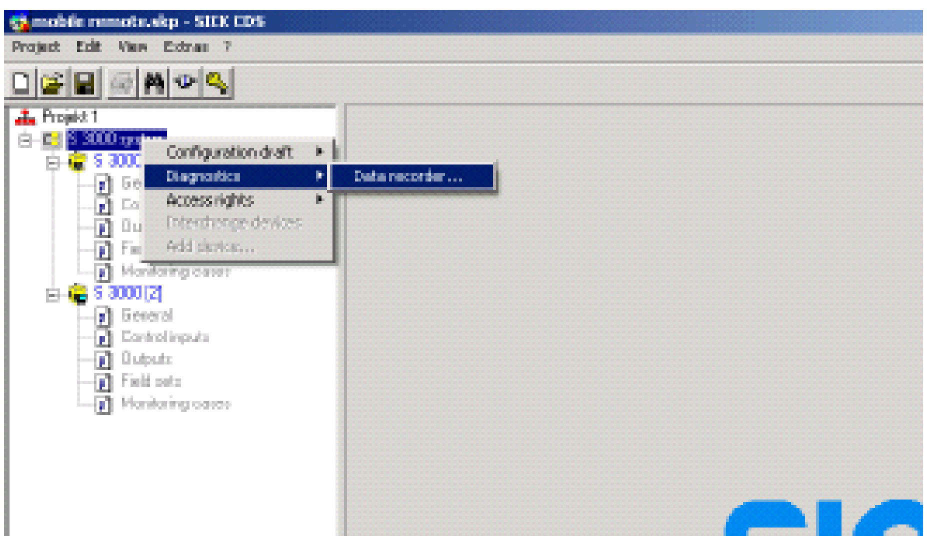


# Laser Front Screen Replacement

- **Never replace the front screen during operation as dust particles could enter the device.  Take the S3000 to clean area for replacement.**
- **Avoid contamination of the inside of the front screen, with fingerprints.**
- **Do not use any additional sealant for sealing the front screen, e.g. silicon, as the vapors produced may damage the interior optics and electronics.**
- **See the vendor manual for details regarding replacement of the screen.**
- The level of contamination is measured continuously during the operation of the S 3000. For this purpose the front screen calibration must first be performed; this then serves as a reference for the contamination measurement (status = not contaminated).
- The front screen calibration should only be performed immediately after the replacement of the front screen!
- **Using CDS go to Device symbol** S 3000**, command** Service**,** Front screen calibration**.**
  - The new front screen must be free of contamination at the time of the front screen calibration. The front screen calibration should be performed at temperature (10–30 °C)!

# Laser Scanner Diagnostics

- CDS (SICK Configuration & Diagnostic Software) software supplied with the device includes extended diagnostic options. It allows you to narrow down the problem if the error is non-specific.
- Use of the CDS Data Recorded provides Extended Diagnostics
- See the SICK manuals located in the vendor chapter of the maintenance manual.




For Scanner systems, open the data recorder via right mouse click on S3000 System and select

*Diagnostics – Data recorder...*

Note:
Individual presentation of each scanner is still possible, see stand-alone procedure.

# CAN I/O PCB I/O

- THE STATUS OF ALL INPUTS ARE MONITORED BY THE VEHCILE MICROCOMPUTER VIA THE CAN BUS.
- ALL INPUT/OUTPUT DEVICES ARE CONNECTED TO THE CAN I/O PCBS.
- THREE CAN I/O PCBS ARE UTILIZED ON THE DC60 AGV:

  * FRONT CAN I/O (BOARD #1): FRONT I/O AND OPP. CHARGE DEVICES.

  * REAR CAN I/O (BOARD #2): REAR I/O.

  *DECK CAN I/O (BOARD #3): Deck Control and Optics.
- EACH PCB HAS A UNIQUE ADDRESS AND EACH I/O POINT ALSO HAS A UNIQUE ADDRESS.
- THE BOARD #, PORT #, AND BIT # CAN BE MONITORED USING ADVANCED DIAGNOSTICS. SEE P. 45 IN TROUBLESHOOTING.
- SEE THE HARDWARE I/O DOCUMENTATION IN THE SOFTWARE SECTION OF THE MANUAL.
- ALL OUTPUTS ARE ACTIVE LOW AND SWITCHED TO GROUND TO ENERGIZE THE DEVICE.
- ALL INPUTS ARE ALSO ACTIVE LOW.

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# CONTROL PANEL ASSEMBLY (FRONT CAN I/O PCB, NAV COMPUTER, VMC COMPUTER, CONVERTERS)


CONVERTER 48V – 5V,12V

NAVIGATION COMPUTER (NC)

VEHICLE MICRO COMPUTER VMC

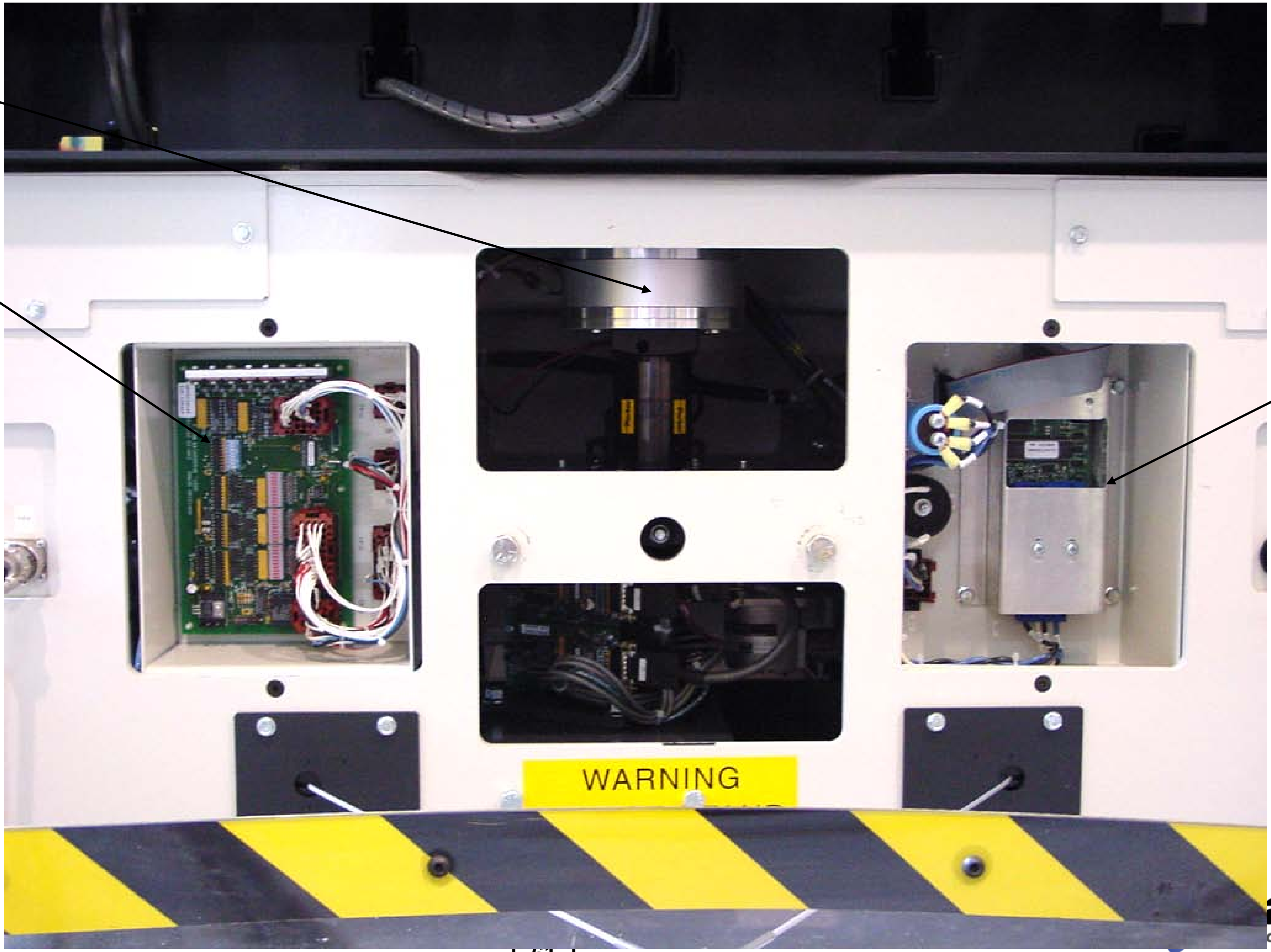
FRONT CAN I/O

CONVERTER 48V – 24V

# REAR PANEL ASSEMBLIES REAR CAN I/O AND REAR STEER PCB- REAR STEER MOTOR/GEAR BOX

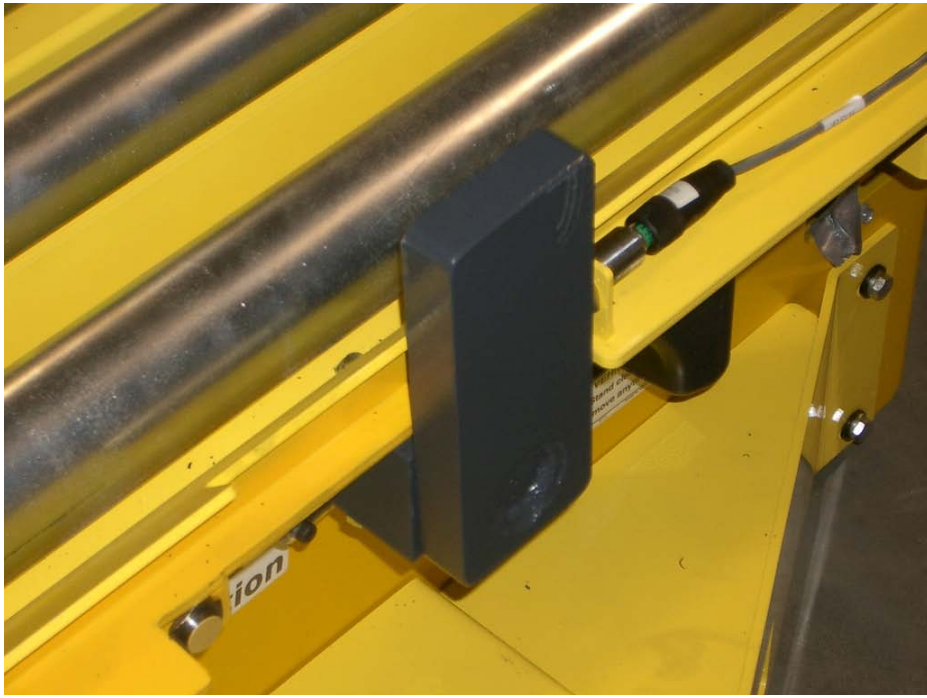
REAR
STEER
MOTOR

REAR
CAN /O



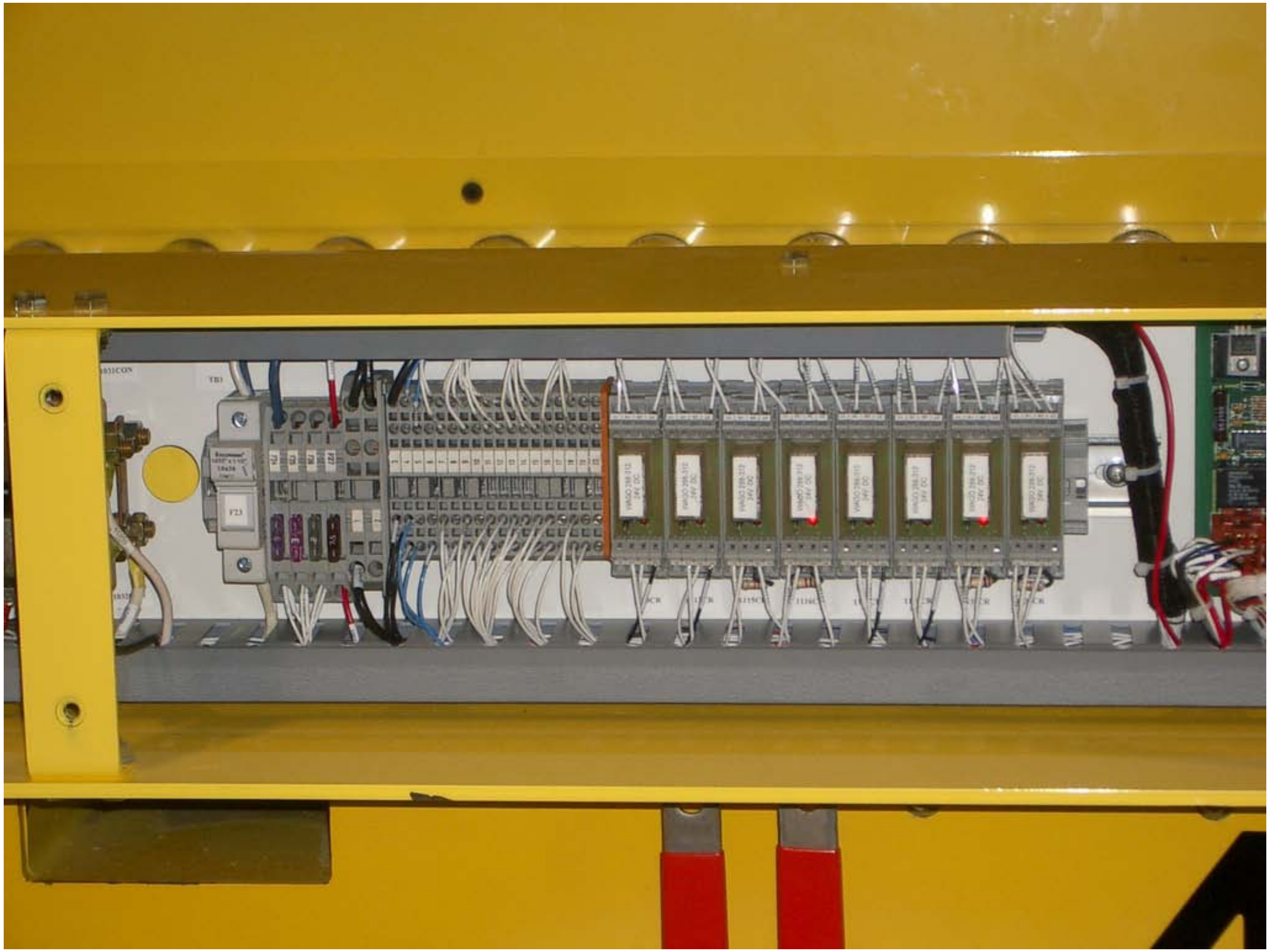

REAR
STEER
PCB

# Deck


Load Stop Prox Sws
UP/DOWN

# Deck Control Panel



# SCHEMATIC OVERVIEW

COMPONENT LABELING DESCRIPTION:

EXAMPLE: 0723SW; = SWITCH AT PAGE #07, LINE #23.

PAGE #

LINE #

DEVICE TYPE

WIRE NUMBER LABELING DESCRIPTION:

EXAMPLE: 03124; = AT PAGE #03, LINE #12, ITEM #4.

PAGE #

LINE #

ITEM #

XXYY — CIRCUIT CONTINUED AT PAGE XX, LINE YY

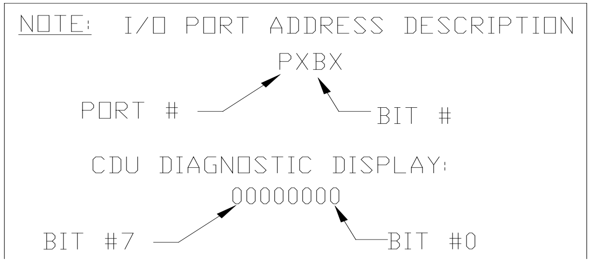
XXYY — DEVICE ALSO SHOWN AT PAGE XX, LINE YY

# SCHEMATIC (CONT.)

- SHEET 2 SHOWS THE BLOCK DIAGRAM AND CAN BE USED TO DETERMINE WHICH SCHEMATIC SHEET TO GO TO.
- USE SHEETS 15,16 TO PHYSICALLY IDENTIFY THE COMPONENTS.
- UTILIZES LADDER (RAIL) TYPE SCHEMATIC.
- ALL INDIVIDUAL WIRES HAVE WIRE #’S; EXCLUDING CABLES.
- SINGLE POINT FRAME GROUND. ALL BLACK WIRES ARE GROUND (# 03002) TYPICALLY.
- ALL BLUE WIRES ARE 48V TYPICAL ; ALL RED WIRES ARE 24V TYPICAL.
- ALL SIGNAL WIRES ARE WHITE; EXCEPT FOR MULTICONDUCTOR CABLES.

# SCHEMATIC (CONT.)

- DEVICES AND WIRE NUMBERS ARE ALL REFERENCED TO THE SHEET AND LINE NUMBER.
- REVIEW SHEET 3 - SAFETY CHAIN.
- REVIEW ALL SHEETS.
- CAN I/O LISTING DESCRIPTION. THE DISPLAY CAN BE USED TO CHECK THE CHANGE OF STATE OF ANY INPUT SIGNAL.
- ALSO SEE THE HARDWARE DOCUMENTATION IN THE SOFTWARE SECTION. THE STATUST OF THE BIT IS MONITORED BY GOING TO THE CORRECT BOARD #, AND PORT #.



# STARTING THE AGV IN AUTO

- INITIALIZE THE AGV AT AN IP POINT AND SWITCH TO AUTO MODE VIA THE PENDANT AND PLACE THE AGV IN “REMOTE” MODE.
- VEHICLE INDICATES “ON Path” and “COM_OK”.
- VEHICLE DESTINATION HAS BEEN ENTERED.
- SAFETY CHAIN IS OK; LINE CONTR. IS ENERGIZED.
- DEPRESS START AND MONITOR THE DISPLAY TO DETERMINE WHY AGV DID NOT START.
- NOTE: WHILE THE AGV IS IN AUTOMATIC OPERATION, THE FLASHING LIGHTS SHOULD ALWAYS BE FLASHING. IF THE LIGHTS ARE NOT FLASHING, THE AGV WAS STOPPED OR FAULTED. THE START SWITCH HAS TO BE PRESSED TO RE-START THE AGV.

# OPERATING THE AGV

- TO PLACE THE VEHICLE INTO THE SYSTEM, IT MUST BE INITIALIZED AT AN IP LOCATION. P_INIT MUST BE DISPLAYED ON THE DISPLAY.
- AFTER INITIALIZATION, VERIFY “ON PATH” INDICATION.
- ENTER DESIRED DESTINATION AND PLACE IN AUTO MODE.
- DEPRESS START AND VIEW START STATUS SCREEN ON DISPLAY TO DETERMINE PROBLEM IF VEHICLE DOES NOT START.
- VEHICLE IS SWITCHED TO “REMOTE” MODE, SO THE VMS COMPUTER CAN DISPATCH THE AGV.
- THE AGV HAS TO REPORT IDLE TO VMS COMPUTER BEFORE IT CAN BE DISPATCHED.
- THE AGV CAN ALSO OPERATE IN “ON BOARD” OR RE-CIRCULATE MODE.

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# TROUBLESHOOTING NAVIGATION PROBLEMS

- INITIALIZE AGV AND VERIFY GUIDANCE ON PATH. MAGNET UPDATES SHOULD BE LESS THEN 1" ON STRAIGHT PATH AND LESS THEN 3" ON TURNS. MONITOR NAV POSITION SCREENS.
- CHECK TO VERIFY ALL NAVIGATION SENSORS ARE COMMUNICATING TO THE NAVIGATION COMPUTER
- CHECK THAT THE CORRECT DATA THROUGH ITS RANGE IS BEING BROADCAST TO THE NAV. COMPUTER.
- USE DIAGNSOSTICS TO CHECK GYRO, MPS, GTS (ANGLE & DME), FRONT DME, AND FRONT/REAR ANGLE.
- REVIEW THE DIAGNOSTIC MENU TREES LOCATED ON P.9 THROUGH P.11 IN TROUBLESHOOTING.

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# TYPICAL NAVIGATION ERRORS

## DME ENCODER FAILURES:

- NAV DME ENCODER ERROR - REAR DME (GTS) COMPLETE FAILURE, VEHICLE WILL GO PINIT HAS TO BE RE-INITIALIZED. IF AGV CAN NOT GET UP TO SPEED, NAV. COMPUTER WILL FAULT.
- TO INITIALLY INITIALIZE VEHICLE, DME COUNTS HAVE TO BE ACCURATE TO DETERMINE IF CORRECT IP MAGNETS ARE SENSED. NAV. USES THE GTS DME.
- IF FRONT DME FAILS, SPEED CONTROL FEEDBACK IS LOST AND SPEED FAULT WILL OCCUR (“FRONT DME NOT RUNNING”).
- USE THE DISPLAY DIAGNOSTICS TO VERIFY THAT THE ENCODERS ARE MEASURING CORRECTLY.

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# ERRORS CONTINUED

STEER OFFSET EXCEEDED:

- IF ANGLE IS GREATER THEN 2 DEGREES OFF CENTER THEN WHAT IS EXPECTED. ANGLE ENCODER SLIPPAGE, GYRO PROBLEM. INCORRECT STEER ADJUSTMENT (LARGE DOG TRACKING).

NVPATH (NO VIRTUAL PATH UNDER VEHICLE)

- MISSED VIRTUAL CODE TO CHANGE PATH, TRACK FILE ERROR, OR MANUAL INTERVENTION.

MISSING MAGNET:

- LOCATION SPECIFIC: BAD MAGNET OR FLOOR PROBLEM.
- VEHICLE SPECIFIC: MAGNET SENSOR PROBLEM OR GTS (DME PROBLEM).



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# NAV. ERRORS CONTINUED

MAG POS ERROR ( LARGE MAGNET UPDATE):

- GTS (ANGLE PROBLEM)
- MAGNET SENSOR PROBLEM
- BAD MAGNET LOCATION (INSTALLATION).

OFF PATH or NVPATH (GREATER THEN 6” FROM VIRTUAL WIRE).

- STEER CONTROL PROBLEM; CHECK STEER COMPONENTS; CHECK STEERING IN MANUAL; CHECK CALIBRATION; CHECK ANGLE DATA.
- SLIPPERY FLOORS.

# DRIVE PROBLEMS

- IF AGV DOES NOT DRIVE IN AUTOMATIC; CHECK IT IN MANUAL.
- IF IT DOES NOT DRIVE IN MANUAL; VERIFY LINE CONTACTOR IS ENERGIZED (SAFEY CHAIN OK). CHECK GREEN LED ON ZAHN SERVOAMP IS ILLUMINATED.
- CHECK THE ENABLE SIGNAL FROM THE ANALOG INTERFACE PCB TO THE ZAHN.
- CHECK THE DRIVE SIGNAL (-5V TO 5V AT THE ZAHN). CHECK THE PENDANT AND ASSOCIATED WIRING. CHECK ZAHN PWM OUTPUT TO MOTORS.
- IF IT DOES NOT DRIVE IN AUTO, CHECK THE START SW. STATUS DISPLAY SCREEN AND ERROR DISPLAYED.
- IN AUTO; CHECK CAN BUS STATUS SPECIFICALLY VMC TO ANALOG INTERFACE PCB.
- IF THE AGV NOT GET UP TO SPEED, A NAV DME ERROR WILL OCCUR. SERVOAMP GAIN MAY HAVE TO BE INCREASED.

# MAINTENANCE MANUAL

- TROUBLESHOOTING SECTION
- REVIEW FLOW CHARTS (P.17 THROUGH P.24).
- CONTROL SYSTEM TROUBLESHOOTING.
- REVIEW PM PROCEDURES IN PM SECTION.
- REVIEW PARTS SECTION AND SPARE PARTS DRAWING.
- REVIEW REPAIRS SECTION AND ADJUSTMENT PROCDEURES.
- REVIEW SOFTWARE LISTING (ERROR CODES).
- REVIEW VMS USER’S MANUAL AND AGVIEW.

# Summary

- Navigation Sensors:

  - Gyro - Heading, rate of rotation, calculates location.

  - Magnet Sensor - Update verification that actual location matched calculated location.

  - Ground Track Sensor - Further angle and DME (distance measuring) feedback form the rear of the AGV.

- Guidance Sensors and Control:

  - Navigation Computer controls steering via the Steer PCB and the Steer Motor.

  - Front/Rear Angle Steer Encoders provide feedback to verify that commanded angle was reached.

- Drive Control:

  - Vehicle Computer commands speed in auto via the Can Analog Interface PCB. The Analog PCB controls the ZAHN Servo-Amp Drive Controller which drives the motor.

- Vehicle I/O:

  - All I/O is connected to the Vehicle Micro Computer via the three CAN I/O PCBs. Computer controls AGV actions based on inputs sensed

# Summary (continued).

- RF Communications:

  - All Traffic Control is accomplished via RF. The AGVs communicate to a Central Computer (CSM) via an RF Base Station. Each AGV has a Transceiver connected to the Vehicle Computer.

  - The CSM acts like a repeater and repeats location info. to all other AGVs.

  - The VMS Computer is connected to the CSM Computer and dispatches the AGVs based on the load status provide by Cummins PLC.